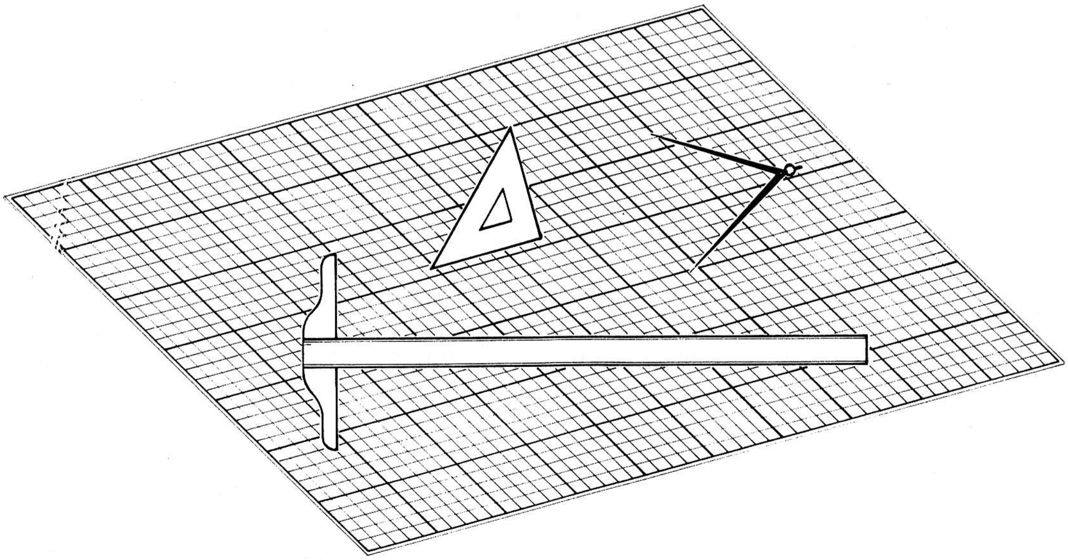
USEFUL

ENGINEERING INFORMATION

FOR DETERMINING FAN REQUIREMENTS

OF BLOW PIPE SYSTEMS IN

WOODWORKING PLANTS, PLANING MILLS, ETC.



Phelps Fan Manufacturing Co., Inc.

LITTLE ROCK, ARKANSAS

FOREWORD

This bulletin is an attempt to explain a procedure for selecting the correct fan size for handling dust and shavings from various machines in woodworking plants. This procedure takes into account only those main factors which are to be considered in conveying the quantities of waste from the machines as it is being made. Where larger quantities of materials of various forms are to be conveyed such as in pneumatic loading, etc., other factors must be considered which are not within the scope of this bulletin.

The information given in this bulletin is not to be considered as conclusive. Various state agencies have set up standards regarding blow pipe systems and the rules governing these standards should be consulted in order to comply with State laws.

For those who wish to pursue further the study of Industrial Exhaust systems the following sources will be found helpful:

"Fan Engineering"—Buffalo Forge Company, Buffalo, N. Y.

"Design of Industrial Exhaust Systems"—John L. Alden,
The Industrial Press.

"Industrial Ventilation" — A Manual of Recommended Practice—
American Conference of Governmental Industrial Hygienists.

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PHELPS FAN MANUFACTURING CO., INC.
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DEFINITIONS AND ABBREVIATIONS

CFM — Cubic Feet of Air Per Minute
VFM — Velocity Feet of Air Per Minute
SP — Static Pressure
VP — Velocity Pressure
HP — Horsepower
V — Velocity
Q — Air Volume (CFM)

To find the CFM flowing through a pipe multiply the Velocity in feet per minute by the area of the pipe in square feet.

To find the VFM in a pipe divide the CFM by the area of the pipe in square feet.

$$\text{The Velocity Pressure} = \left(\frac{V}{4005}\right)^2$$

$$\text{Velocity (VFM)} = 4005\sqrt{VP}$$

TROUBLE SHOOTING BLOW PIPE SYSTEMS

There are a number of things to try when a system is undersize as a result of miscalculation or from adding on to an existing system.

1. Speed Up Fan RPM
    a. This will give you more air at a greater velocity. Both CFM and velocity varies directly as the RPM. However, at the same time the horsepower will increase as the cube of the RPM. Therefore, you must be careful that you do not overload the motor. It may be necessary to install a larger motor. Also you should check with fan manufacturer to find out the maximum recommended speed for the fan in question.
2. Improve Piping System
    a. Pipe size may be too small. The **area** of the discharge pipe should at least be equal to **total area** of all branch pipes on inlet side of fan. See diagram Fig. 1.
    b. Cyclone size may be too small. See Fig. 5.
    c. Sharp elbows should be eliminated—center line radius should be at least two pipe diameters.
    d. If system is blowing into a fuel house be sure there is ample opening for air to escape.
    e. If possible shorten total length of system. This will increase the air at a given speed and reduce pressure.
    f. Make sure fan is running in the right direction. It has been said that 50% of fan problems is caused by not checking to see if fan is running in right direction. A fan will move some air if running backwards but it will be far below the amount expected.
    g. Make sure pipe is not clogged at some point.

HOW TO SELECT THE CORRECT SIZE OF PHELPS FAN FOR A BLOW PIPE SYSTEM

The correct size fan for a particular blow pipe system depends upon the size of the main intake and discharge pipes which have been calculated to be necessary for the system.

Table No. 1 – Page 18 shows the sizes of Phelps fans which are recommended for various sizes of main pipes.

The example below shows how to compute the size of the main intake and discharge pipes in a woodworking plant according to the following procedure:

1. Determine the correct size of each branch inlet pipe from Table No. 4.

2. The main inlet pipe will have an area (in square inches) at any one point equal to the sum of the areas of all branch pipes leading into it. See Table No. 9 for areas of various pipe sizes. See Fig. 2 for recommended branch entry designs. The area of floor sweep pipes is not to be included in computing main pipe size.

3. The area of the main inlet pipe nearest the fan or after all branch pipes have been added to it will be the size of the main discharge pipe. The area of the main inlet and discharge pipe may be as much as 10% greater than the combined area of all branch inlet pipes, or more provided the velocity does not fall below that necessary to convey the material.

4. Select the proper size Phelps fan from Table No. 1 which is recommended for the size of main inlet and discharge pipes just found. Use next larger fan when pipe size falls between fan sizes.

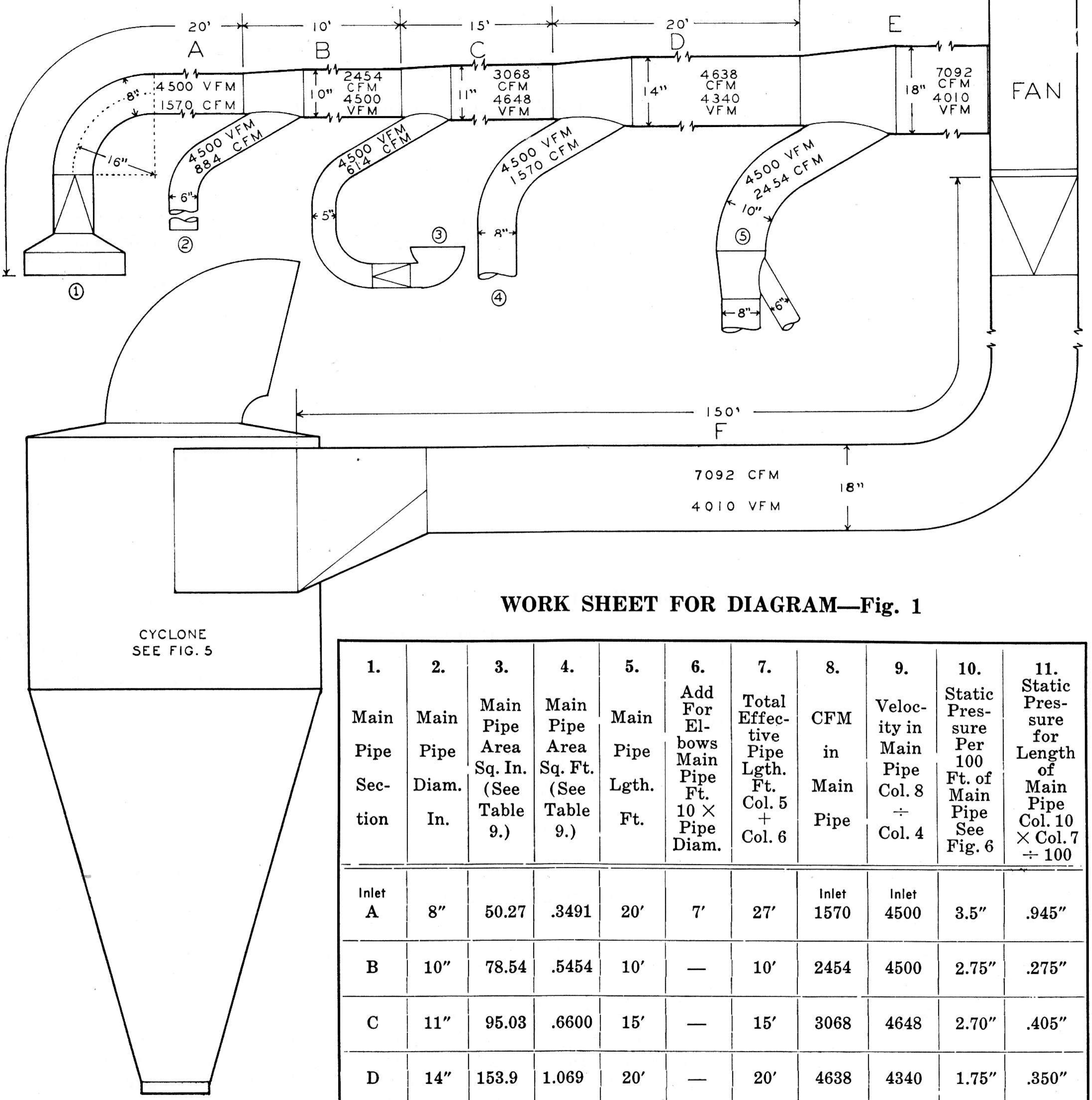
EXAMPLE See diagram of Blow Pipe System, Fig. 1

Branch Inlet Pipes				**Main Inlet Pipe**		
Designation 1.	**Diameter Inches** 2.	**Area Sq. In.** 3.	**Total Area Sq. In.** 4.	**Designation** 5.	**Diam. In. having an area not greater than 10% of Col. 4** 6.	**Area Sq. In.** 7.
①	8″	50.27	50.27	A	8″	50.27
②	6″	28.27	78.54	B	10″	78.54
③	5″	19.64	98.18	C	11″	95.03
④	8″	50.27	148.45	D	14″	153.90
⑤	10″	78.54	226.99	E	18″	254.50

5. The main inlet pipe nearest the fan or after all branch inlet pipes have been added is found to be 18″ diameter. Therefore the discharge pipe will be 18″ diameter.

Note: For Grinding and Buffing Operations it is good practice to make the main inlet pipe about 20% greater than the combined area of all branch pipes leading into it.
The area of floor sweep pipes need not be included in computing main pipe area.

DIAGRAM FIG. 1.



WORK SHEET FOR DIAGRAM—Fig. 1

1. Main Pipe Section	2. Main Pipe Diam. In.	3. Main Pipe Area Sq. In. (See Table 9.)	4. Main Pipe Area Sq. Ft. (See Table 9.)	5. Main Pipe Lgth. Ft.	6. Add For Elbows Main Pipe Ft. 10 × Pipe Diam.	7. Total Effective Pipe Lgth. Ft. Col. 5 + Col. 6	8. CFM in Main Pipe	9. Velocity in Main Pipe Col. 8 ÷ Col. 4	10. Static Pressure Per 100 Ft. of Main Pipe See Fig. 6	11. Static Pressure for Length of Main Pipe Col. 10 × Col. 7 ÷ 100
Inlet A	8″	50.27	.3491	20′	7′	27′	Inlet 1570	Inlet 4500	3.5″	.945″
B	10″	78.54	.5454	10′	—	10′	2454	4500	2.75″	.275″
C	11″	95.03	.6600	15′	—	15′	3068	4648	2.70″	.405″
D	14″	153.9	1.069	20′	—	20′	4638	4340	1.75″	.350″
E	18″	254.5	1.767	10′	—	10′	7092	4010	1.10″	.110″
Discharge F	18″	254.5	1.767	150′	15′	165′	Discharge 7092	Discharge 4010	1.10″	1.815″
Inlet Resistance = V.P. at 4500 VFM = 1.27″ (Table 6.) ½ × 1.27″ = .63″										.63″
Cyclone Resistance = V.P. at 4010 VFM = 1.00″ (Table 6.) 1 × 1.00″ = 1.00″										1.00″
Total — S.P. for this System — Col. 11										5.53″

FIND THE CORRECT FAN SPEED

The correct speed at which to operate the fan will depend upon the following main factors:

1. The CFM to be handled at the required air velocity.
2. The pressure required to force this CFM through the piping system. This is known as the Static Pressure.

COMPUTE THE CFM

1. For light dry shavings and dust from small woodworking machines an air velocity of from 4000 to 4500 feet per minute is usually adequate. For green sawdust and shavings a velocity of 5000 feet per minute and for large planers an air velocity of about 6000 feet per minute should be maintained in the **branch inlet** pipes. An air velocity of from 4000 to 4500 feet per minute should be adequate in the **main** intake and **discharge** pipes. See Table No. 5 for conveying velocities for various types of materials.
2. In the diagram Fig. 1 we have assumed an air velocity of 4500 feet per minute in the branch inlet pipes.
3. The total CFM in this system (Fig. 1) will be the sum of the CFM entering all of the branch inlet pipes on the suction side of the fan. The total CFM is computed as follows:

   Multiply the selected air velocity (4500 VFM) by the square feet area of each branch inlet pipe and find the total. Thus:

Branch Inlet Pipe Designation, Fig. 1		
①	The area of an 8″ diameter Pipe in square feet is (See Table No. 9)	.3491 Sq. Ft.
	Therefore the CFM in this 8″ Pipe is	4500 × .3491 = 1570 CFM
②	The CFM in a 6″ Pipe at 4500 VFM is	4500 × .1964 = 884 CFM
③	The CFM in a 5″ Pipe at 4500 VFM is	4500 × .1364 = 614 CFM
④	The CFM in an 8″ Pipe at 4500 VFM is	4500 × .3491 = 1570 CFM
⑤	The CFM in a 10″ Pipe at 4500 VFM is	4500 × .5454 = 2454 CFM
	Therefore the total CFM required by the system is	7092 CFM

It is now necessary to determine whether or not the **main** inlet pipe in each of its sections and also the discharge pipe has sufficient air velocity in them to convey the materials — or at least 4000 VFM. This is done in the following manner:

Section of Main Inlet Pipe, Fig. 1	
B — 10″ Diam.	The area of the 10″ Diam. section of the main inlet pipe will have coming into it the total CFM from both the 8″ and the 6″ branch inlet pipes or a total CFM of 1570 + 884 or 2454 CFM. This total CFM divided by the area (in square feet) of this 10″ pipe section of the main inlet pipe will give an air velocity in this 10″ section of pipe as follows: 2454 ÷ .5454 = 4500 VFM — Which is sufficient
C — 11″ Diam.	3068 ÷ .6600 = 4648 VFM — " " "
D — 14″ Diam.	4638 ÷ 1.069 = 4340 VFM — " " "
E — 18″ Diam.	7092 ÷ 1.767 = 4010 VFM — " " "
Discharge	
F — 18″ Diam.	7092 ÷ 1.767 = 4010 VFM — " " "

The work sheet following the diagram Fig. 1 of the blow pipe system presents a convenient method of arranging this information.

COMPUTE THE STATIC PRESSURE AGAINST WHICH THE FAN IS TO OPERATE

The Static Pressure against which the fan is to operate depends upon the following main factors:

1. Pipe Resistance
2. The Inlet Resistance
3. The Cyclone or Collector Resistance
4. The Altitude and Temperature

The Altitude and Temperature factors can generally be ignored unless the Altitude is above about 1500 Ft. and the Temperature is above about 125° F. Page 22 shows the method for applying these factors when necessary.

Additional data should now be added to the work sheet under the Diagram (Fig. 1) to arrange the information necessary to calculate the Static Pressure.

PIPE RESISTANCE

The CFM in each section of the main inlet pipe was entered on the work sheet in Column No. 8. The total effective pipe length (as computed below to include elbows) for each section of the main inlet pipe is entered in Column No. 7. These two columns are the basis for computing the Static Pressure of the system, not including inlet and cyclone resistances.

1. Select **only** the longest branch inlet run from the fan which is shown in the diagram as pipe No. ① This 8″ pipe which is indicated as "A" is 20 feet long and has one elbow.

   A 90° elbow which has a center line radius equal to at least twice its diameter can be considered to be equivalent in pipe length to ten times its diameter. See Fig. 3. Also see Table 10 on page 24.

   Therefore — 20′ + (10 × 8″) = 20′ + 7′ = 27′ or the effective total pipe length for this section.

2. Enter the pipe diameter and length of each section of the main inlet pipe on the work sheet in Cols. No. 2 and No. 5. Compute the additional pipe lengths on account of elbows and enter in Col. No. 6. Enter the total effective pipe length for each section in Col. No. 7. The Static Pressure is based on the diameter and length of the pipe and the CFM flowing through it.
3. From the air chart (Fig. 6) find the Static Pressure **per hundred feet** of pipe for each diameter of the main inlet pipe and for the discharge pipe and enter in Col. 10 on the work sheet.
4. Calculate the Static Pressure for the total length of each section of the main inlet pipe (Col. No. 7) and enter in Col. No. 11.
5. Calculate the Static Pressure for the total length of the discharge pipe and enter in Col. No. 11.
6. Now, apply step 2 – in Fig. 8 page 25 if CFM per lb. is 40 or less.
7. Also, if material is to pass through fan apply step 5 on Fig. 8 page 25 if CFM per lb. is 40 or less.

INLET RESISTANCE

Inlet resistance is based on the amount of Velocity **Pressure** produced by the required air Velocity at the pipe entrance.

Table No. 6 shows the Velocity Pressure for various air velocities.

Figure 4 shows various designs of pipe inlet construction and the loss in percentage of Velocity Pressure for each type of entry. Experience has found that most hoods on woodworking machinery may be considered to produce an inlet loss of approximately 50% of the Velocity pressure.

Table No. 6 shows that the Velocity Pressure at an air velocity of 4500 VFM is equal to 1.26″ VP. Therefore the inlet resistance for the branch pipes in our diagram may be computed as follows:

$$\frac{1}{2} \times 1.26'' \text{ VP} = .63'' \text{ SP}$$

Enter as the inlet resistance .63″ SP in Col. No. 11 on the work sheet.

CYCLONE OR COLLECTOR RESISTANCE

The Static Pressure resistance offered by a cyclone is based on the velocity of the air entering it and also upon its dimensions.

Figure 5 shows recommended dimensions for the construction of cyclones and is based on the volume of air entering it.

The resistance (SP) caused by a cyclone of appropriate dimensions will be from .60 to 100% of the Velocity Pressure.

In our diagram (Fig. 1) if we assume a cyclone resistance of 100% of the Velocity Pressure then the Static Pressure to be included in the system on account of the cyclone resistance will be as follows:

> Velocity of the air entering the cyclone is 4010 VFM.
>
> Velocity Pressure at 4010 VFM is 1.00″. (See Table No. 6.)
>
> Therefore — 100% of 1.00″ VP = 1.00″ SP.

Enter 1.00″ SP in Col. 11 on the work sheet as cyclone resistance.

The total of Col. 11 gives the total amount of Static Pressure required by this system.

SUMMARY

The final requirements for the Blow Pipe System in the diagram Fig. 1 can now be summarized as follows:

Total CFM required	Column 8	7092 CFM
Total Static Pressure	Column 11	5.53″ SP
Main Discharge Pipe	Columns 1 & 2	18″ Diam.
Main Inlet Pipe	Columns 1 & 2	8″, 10″, 11″, 14″, 18″ Diam.
Size of Phelps Fan required (see Table No. 1)		50″ Model "R"
Fan Speed required (see Performance Data Chart)		1000 RPM
Horsepower required (see Performance Data Chart)		17.5 HP

Note: Select the fan speed section in the Performance Data Chart which will give **not less** than the required CFM at the required SP.

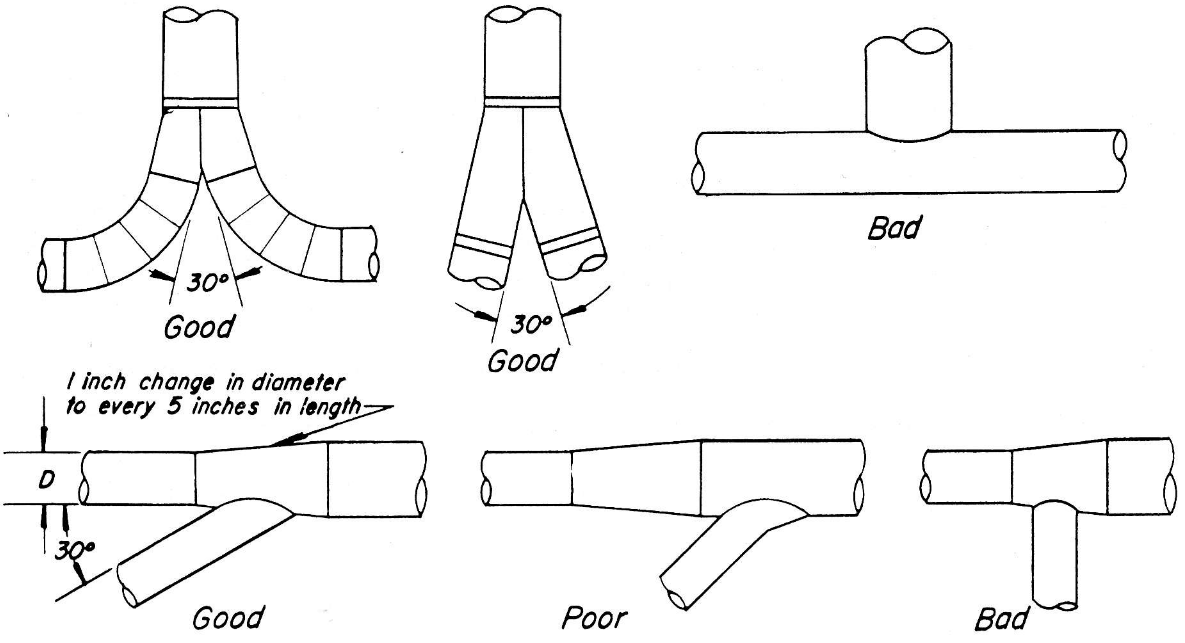
WORK SHEET

For Blow Pipe Systems

1. Main Pipe Section	2. Main Pipe Diam. In.	3. Main Pipe Area Sq. In. (See Table 9.)	4. Main Pipe Area Sq. Ft. (See Table 9.)	5. Main Pipe Lgth. Ft.	6. Add For Elbows Main Pipe Ft. 10 × Pipe Diam.	7. Total Effective Pipe Lgth. Ft. Col. 5 + Col. 6	8. CFM in Main Pipe	9. Velocity in Main Pipe Col. 8 ÷ Col. 4	10. Static Pressure Per 100 Ft. of Main Pipe See Fig. 6	11. Static Pressure for Length of Main Pipe Col. 10 × Col. 7 ÷ 100
See instructions for adding static pressure & horsepower — page 25										
Inlet Resistance = V.P. at V.F.M.										
Cyclone Resistance = V.P. at V.F.M.										
Total — S.P. for this System — Col. 11										

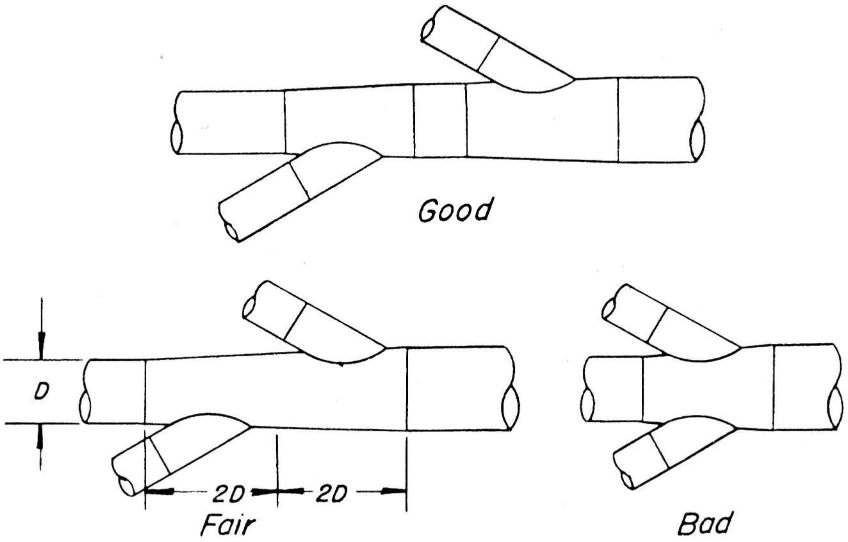
Phelps Fan Manufacturing Co., Inc.

LITTLE ROCK, ARKANSAS

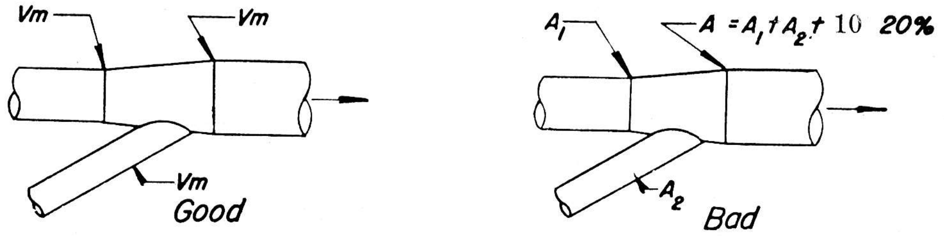


BRANCH ENTRY

Branches should enter at gradual expansions and at an angle of 30° or less (preferred) to 45° if necessary.



BRANCH ENTRY– *Branches should not enter directly opposite each other.*



Vm = Minimum transport velocity
A = Cross section area.

PROPER DUCT SIZE *Size the duct to hold the selected transport velocity or higher.*

Fig. 2

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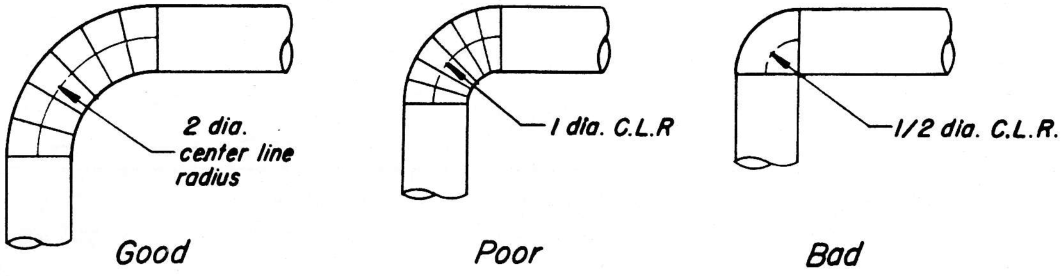
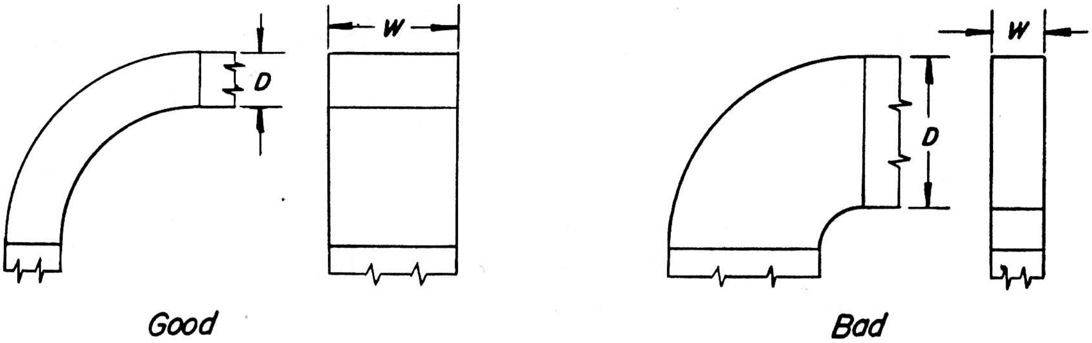
PRINCIPLES OF DUCT DESIGN



ELBOW RADIUS

Elbows should be 2 or 2 1/2 diameters centerline radius except where space does not permit.



ASPECT RATIO

Keep AR ($\frac{W}{D}$) high in using rectangular duct.

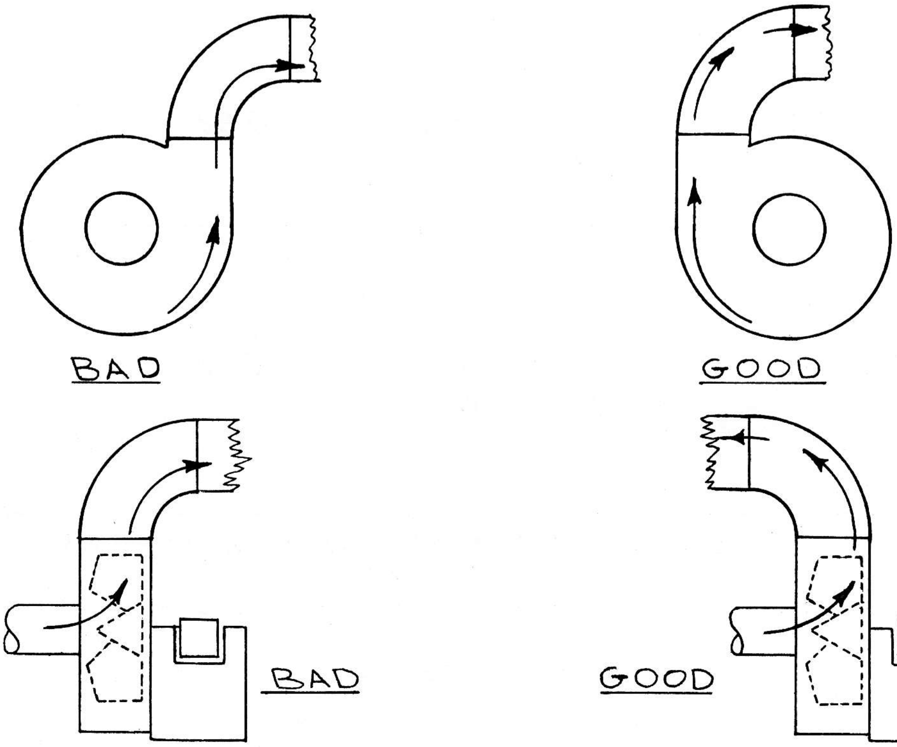


Fig. 3

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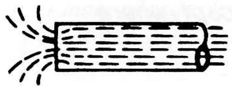
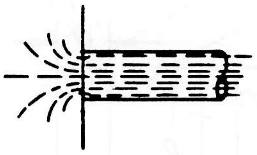
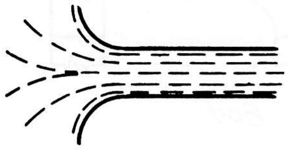
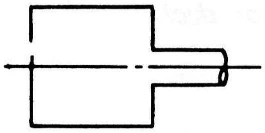
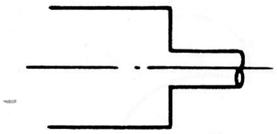
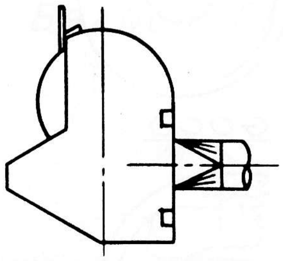
Type of Opening	Description	Coefficient of Entry C_e	Loss in % of Velocity Head h_e
	Plain duct end	0.72	93
	Flanged duct end	0.82	49
	Well rounded entry	0.98	4
	Orifice plus flanged duct	0.49	2.3
	Direct branch booth	0.82	49
	Standard grinder hood	0.78	65

Entry Coefficients for Different Shape Hoods

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Fig. 4

STANDARD CYCLONE DIMENSIONS

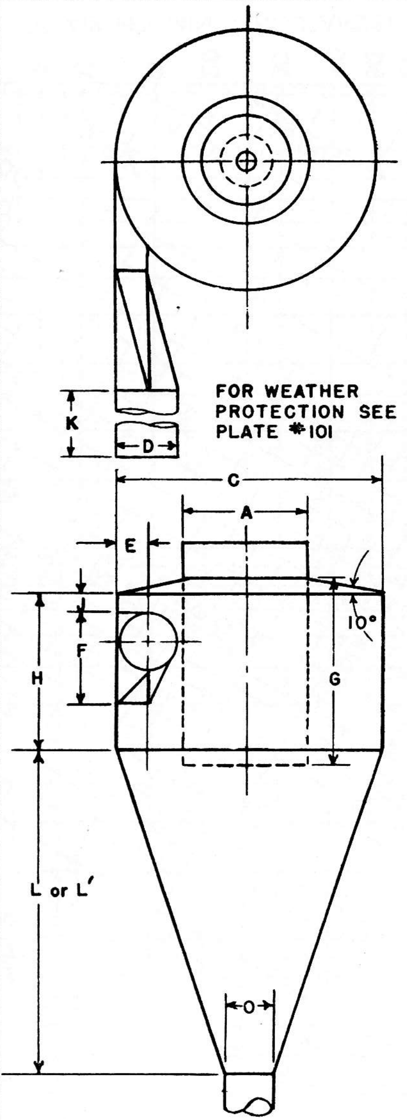
Maximum System Capacity	Approx. Main Pipe Diam.	Rectangular Inlet Size	Air Outlet Diam.	Dust Outlet Diam.	Cylinder Diam.	Cylinder Height	Cone Length (Normal)	Cone* Length (Long)
CFM	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
Symbol**	D	E X F	A	O	C	H	L	L¹
550	5	2x10	10	4	28	15	28	42
800	6	3x10	12	4	34	18	34	50
1100	7	3½x11	14	6	37	20	38	56
1400	8	4x12	16	6	39	22	41	62
1750	9	4½x14	18	6	40	24	45	68
2000	10	5x15	20	6	42	25	50	75
2200	11	5½x16	22	10	46	27	54	81
2500	12	6x18	24	10	50	30	57	86
2800	13	6½x18	26	10	54	32	60	90
3300	14	7x21	28	10	59	35	64	96
3800	15	7½x22	30	10	63	37	68	102
4300	16	8x24	32	10	67	40	72	108
5000	17	8½x26	34	10	72	42	75	112
5500	18	9x28	36	10	76	45	78	116
6200	19	9½x29	38	10	80	47	82	124
7000	20	10x30	40	10	84	50	85	128
7800	21	10½x32	42	10	88	52	88	132
8600	22	11x34	44	10	92	55	92	138
10400	24	12x37	48	12	100	60	99	148
12200	26	13x40	52	12	110	65	106	160
14000	28	14x43	56	12	118	70	114	170
16000	30	15x46	60	12	126	75	120	180
18000	32	16x50	64	12	134	80	128	190
20000	34	17x54	68	14	144	85	134	200
22000	36	18x56	72	14	152	90	142	212
26000	38	19x60	76	14	160	95	148	222
30000	40	20x62	80	14	168	100	156	234

* For finer dusts, the long cone dimension is more effective.

** Symbols correspond to those shown for cyclone proportions.

NOTE: The above dimensions represent a consensus of industrial practice for separation of dusts of larger particle sizes. Construction conforming to these dimensions may be used where dust separation by means of a cyclone is approved by the Industrial Commissioner.

CYCLONE PROPORTIONS



FOR WEATHER PROTECTION SEE PLATE #101

ELEMENTS OF CYCLONE AS RELATED TO INLET PIPE DIAMETER

A	2D	AIR OUTLET
C	4.2 D	CYLINDER DIAMETER
D	D	DIAM. MAIN INLET
E	0.5 D	INLET WIDTH
F	1.5 D	INLET HEIGHT
G	3 D	INNER CYLINDER HEIGHT
H	2.5 D	OUTER CYLINDER HEIGHT
J	3"	INLET CLEARANCE
K	7.5 D min.	STRAIGHT APPROACH
L	3.5 D+15	LENGTH OF CONE
L′	1.5 L	LENGTH OF LONG CONE
O	SEE TABLE	DUST OUTLET DIAM.

TABLE OF MINIMUM DIMENSIONS & GAUGES

D	5"-10"	11"-22"	24"-32"	<34"
O	6"	10"	12"	14"
CYLINDER	22 ga	20 ga	18 ga	18 ga
CONE	20 ga	18 ga	16 ga	16 ga

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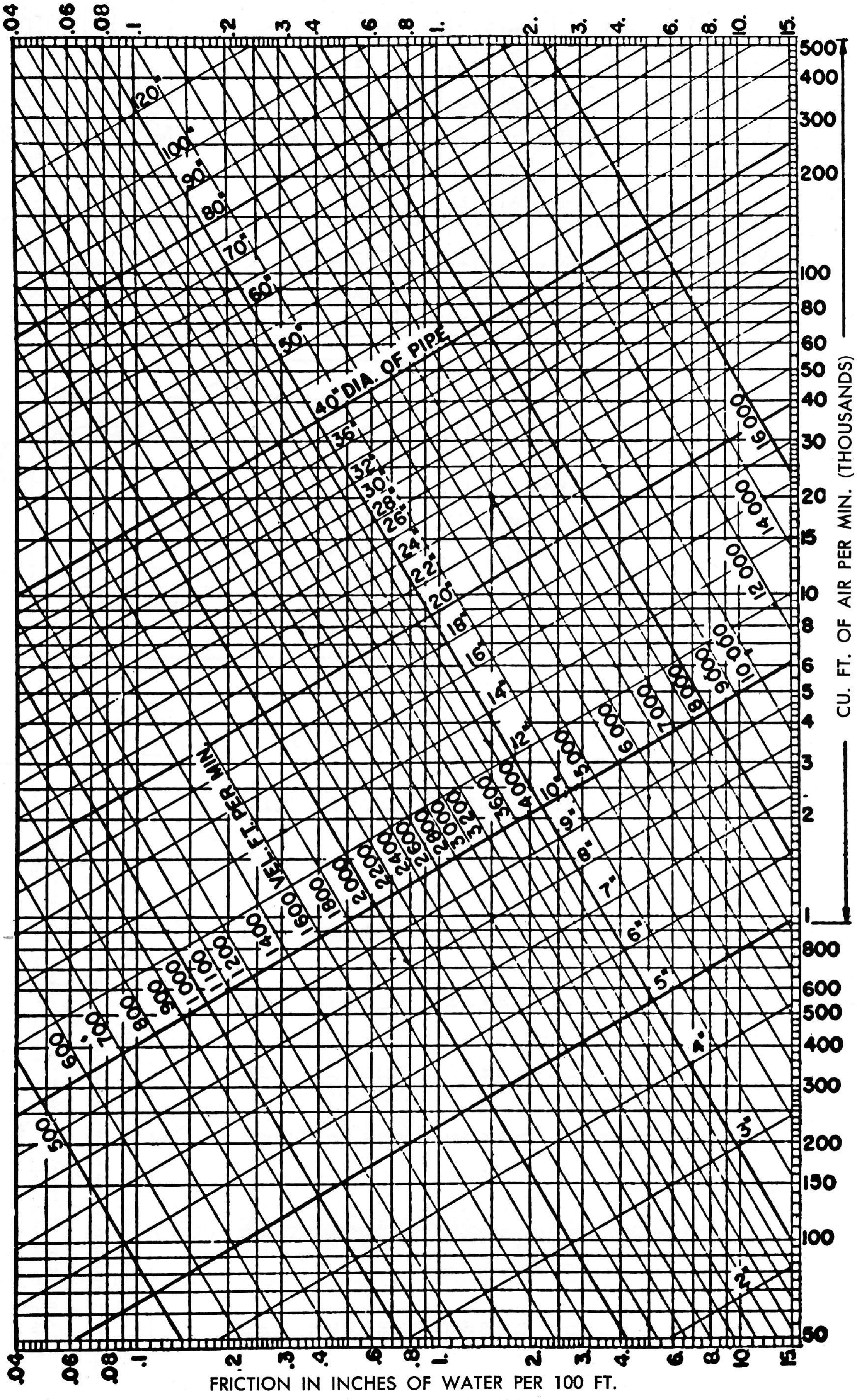
Fig. 5



Friction of Air in Pipes

Fig. 6

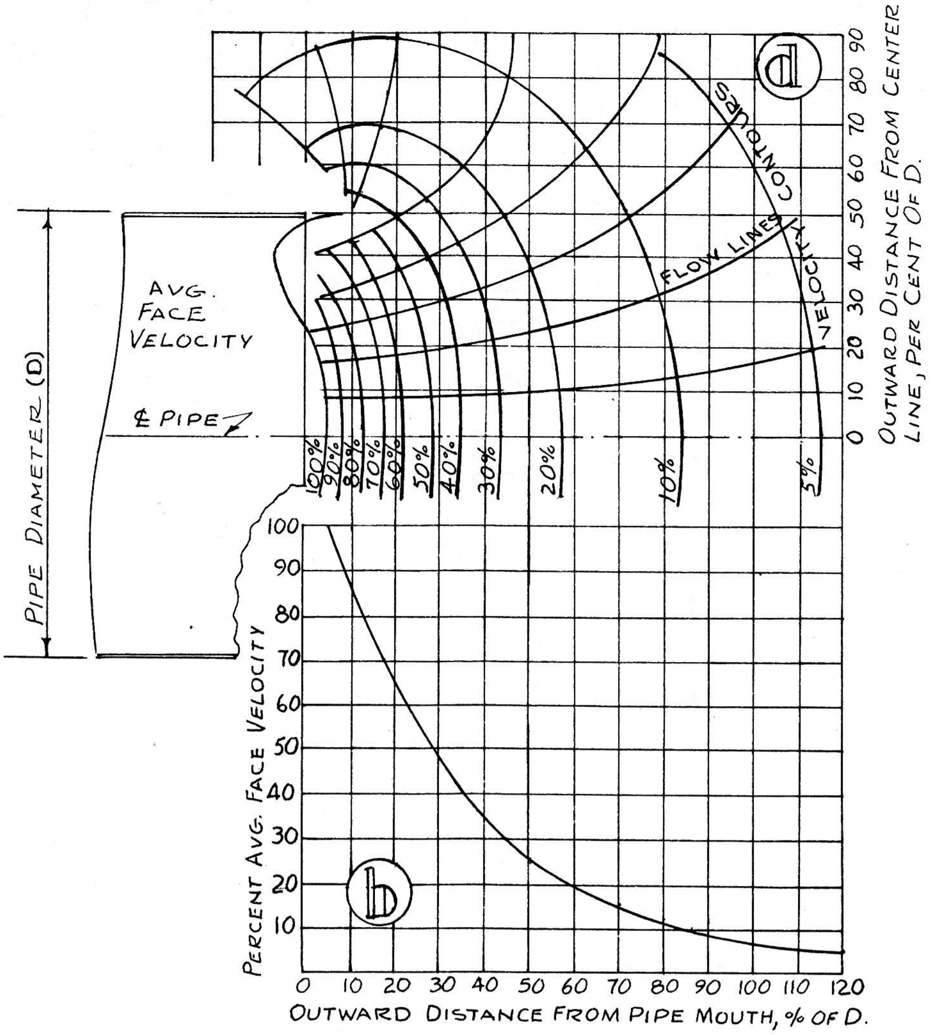


Fig. 7

Fig. 7 Shows why a suction hood cannot be expected to divert a dust particle at a considerable distance from the hood mouth. Let us assume that a dust particle flying in space requires an air velocity of 1000 feet per minute to deflect it into the hood. Assume a 6″ diameter pipe and the dust particle one pipe diameter, or 6″, away from the end of the pipe and assume a face velocity of 4000 feet per minute at the pipe end. Then note from Fig. 7, at 100% on the horizontal axis, that at 6″ from the pipe the velocity will be only about 7% of the 4000 F.P.M. or 280 F.P.M. This is plainly insufficient to capture the particle. The pipe end must approach the flying particle to within a distance of 3″ or less before it could be diverted into the pipe by the in-rushing air.

The zone of influence of exhaust air currents is narrowly restricted to the immediate region of the hood face. This is in sharp contrast to the ability of a pressure jet to "reach out" to relatively great distances from a nozzle. Consequently, exhaust hoods must be placed very close to the source of dust; must embrace it; or must be placed so that the natural trajectories of the dust grains terminate in the hood mouth.

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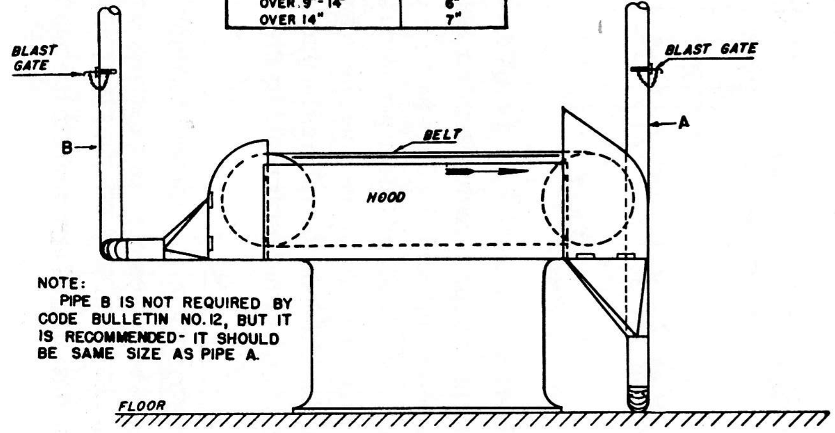
MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12

BELT WIDTH	PIPE A
LESS THAN 6"	4.5"
6"-9"	5"
OVER 9"-14"	6"
OVER 14"	7"

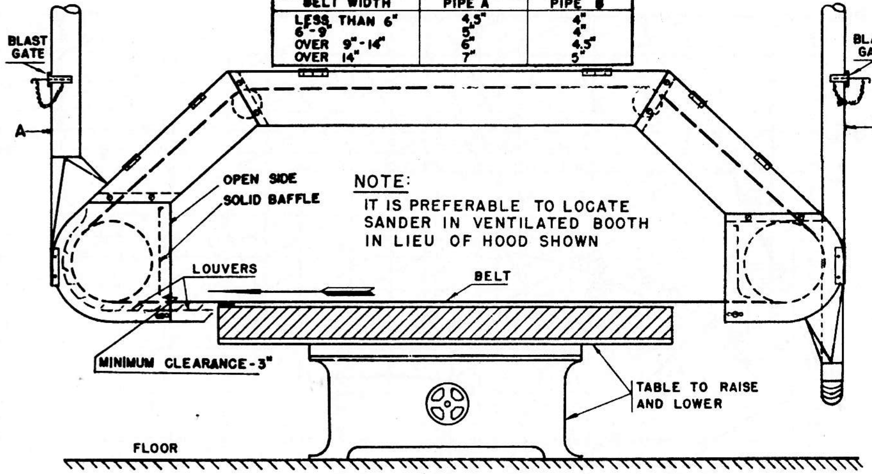


NOTE:
PIPE B IS NOT REQUIRED BY CODE BULLETIN NO. 12, BUT IT IS RECOMMENDED- IT SHOULD BE SAME SIZE AS PIPE A.

BELT SANDER
TOP RUN OF BELT USED

MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12

BELT WIDTH	PIPE A	PIPE B
LESS THAN 6"	4.5"	4"
6"-9"	5"	4"
OVER 9"-14"	6"	4.5"
OVER 14"	7"	5"

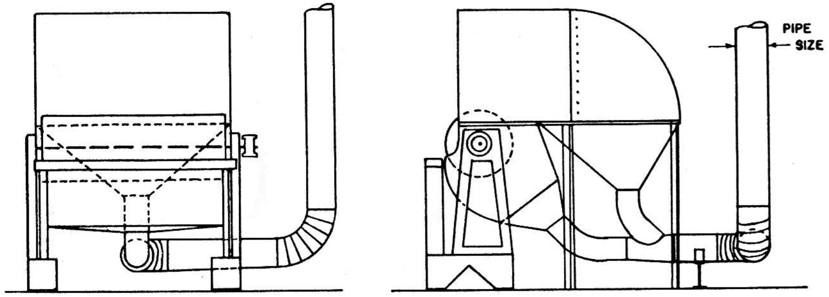


NOTE:
IT IS PREFERABLE TO LOCATE SANDER IN VENTILATED BOOTH IN LIEU OF HOOD SHOWN

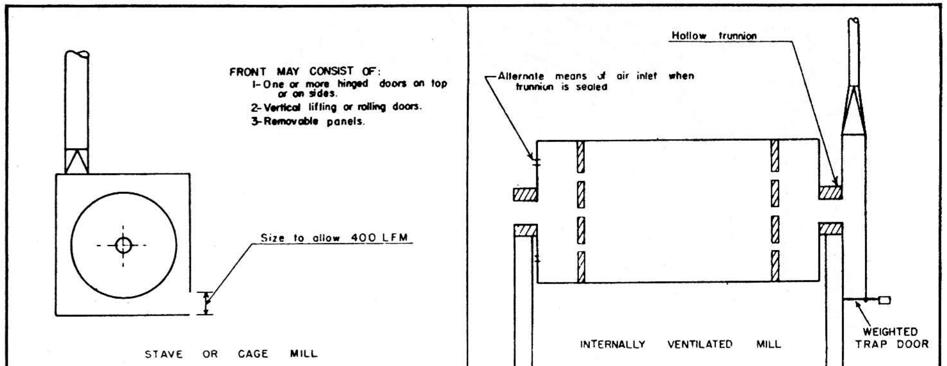
BELT SANDER
BOTTOM RUN OF BELT USED

MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12

DRUM DIA.	WORKING SURFACE	PIPE SIZE
Up to 10"	Up to 200 sq. in.	4"
Over 10"	Up to 400 sq. in.	4½"
	Over 400-700 sq. in.	5"
	Over 700-1400 sq. in.	6"
	Over 1400-2400 sq. in.	7"



DRUM SANDER


FRONT MAY CONSIST OF:
1- One or more hinged doors on top or on sides.
2- Vertical lifting or rolling doors.
3- Removable panels.
Size to allow 400 LFM
Hollow trunnion
Alternate means of air inlet when trunnion is sealed
WEIGHTED TRAP DOOR

STAVE OR CAGE MILL

INTERNALLY VENTILATED MILL

Inside dimension of stave mill not over 70 in. inside length		Air to be exhausted C.F.M.
Side of square mill	Diameter of round mill	
	Up to 24" inc.	800
Up to 24" inc.	30"	900
30"	36"	980
36"	42"	1335
42"	48"	1747
48"	54"	2210
54"	60"	2725
60"	66"	3300
66"	72"	3925
72"		4610

NOTE:

1. Dust-tight drums with no openings to the room when loaded require no enclosure except where drum loading and unloading are dusty operations.
2. Non-dust tight drums and all drums rotated with cage or mesh doors must be enclosed and ventilated in the same manner as cages or stave mills.
3. Enclosure and air velocity of not less than 100 LFM into loading or unloading openings required where these operations are dusty.

Inside dimension of mill		AIR to be exhausted CFM	Minimum branch diameter
Side of square mill	Diameter of round mill		
....	Up to 24" inc.	430	4"
Up to 24" inc.	30"	680	5"
30"	36"	980	6"
36"	42"	1335	7"
42"	48"	1750	8"
48"	54"	2200	9"
54"	60"	2730	10"
60"	66"	3300	11"
66"	72"	3920	12"
72"	......	4600	13"

TUMBLING MILLS, BARRELS CAGES & DRUMS

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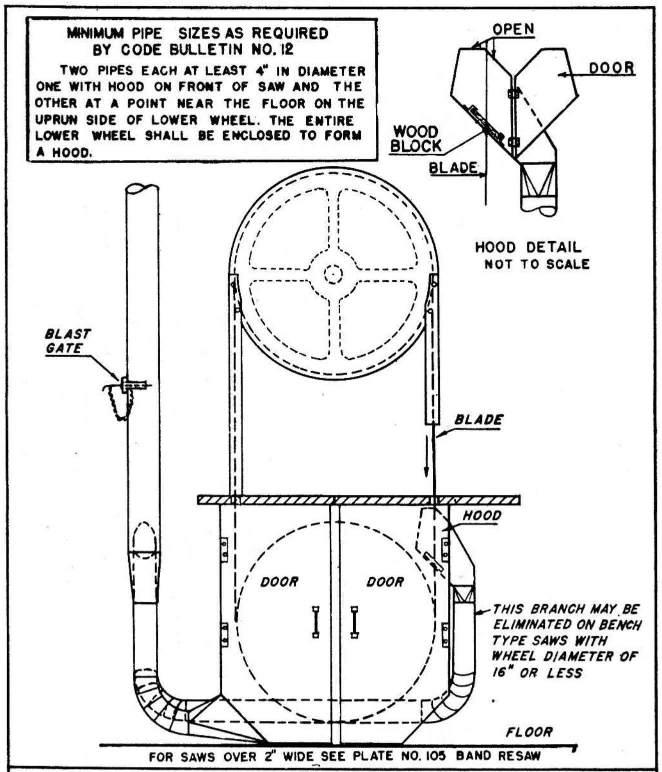


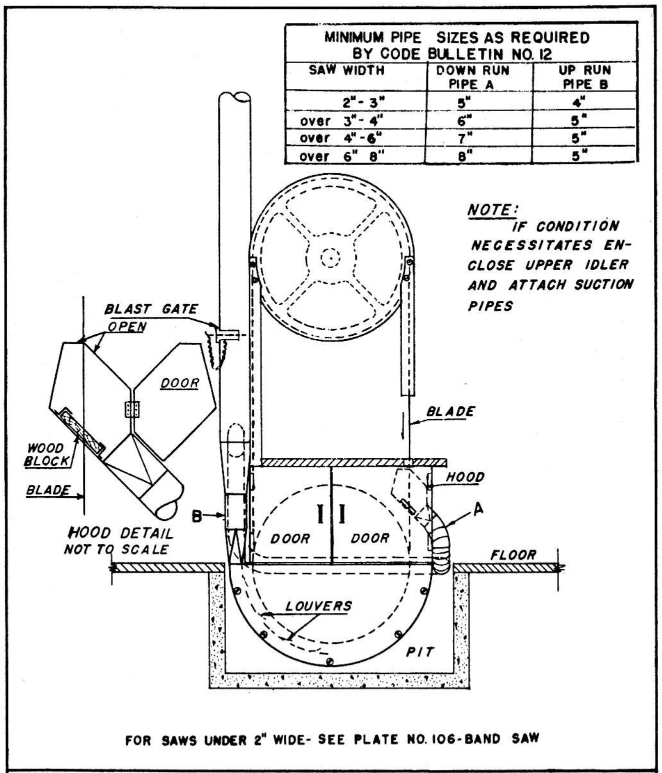
MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12

TWO PIPES EACH AT LEAST 4" IN DIAMETER ONE WITH HOOD ON FRONT OF SAW AND THE OTHER AT A POINT NEAR THE FLOOR ON THE UPRUN SIDE OF LOWER WHEEL. THE ENTIRE LOWER WHEEL SHALL BE ENCLOSED TO FORM A HOOD.

THIS BRANCH MAY BE ELIMINATED ON BENCH TYPE SAWS WITH WHEEL DIAMETER OF 16" OR LESS

FOR SAWS OVER 2" WIDE SEE PLATE NO. 105 BAND RESAW

BAND SAW



MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12		
SAW WIDTH	DOWN RUN PIPE A	UP RUN PIPE B
2"- 3"	5"	4"
over 3"- 4"	6"	5"
over 4"-6"	7"	5"
over 6" 8"	8"	5"

NOTE: IF CONDITION NECESSITATES ENCLOSE UPPER IDLER AND ATTACH SUCTION PIPES

FOR SAWS UNDER 2" WIDE- SEE PLATE NO. 106-BAND SAW

BAND RESAW

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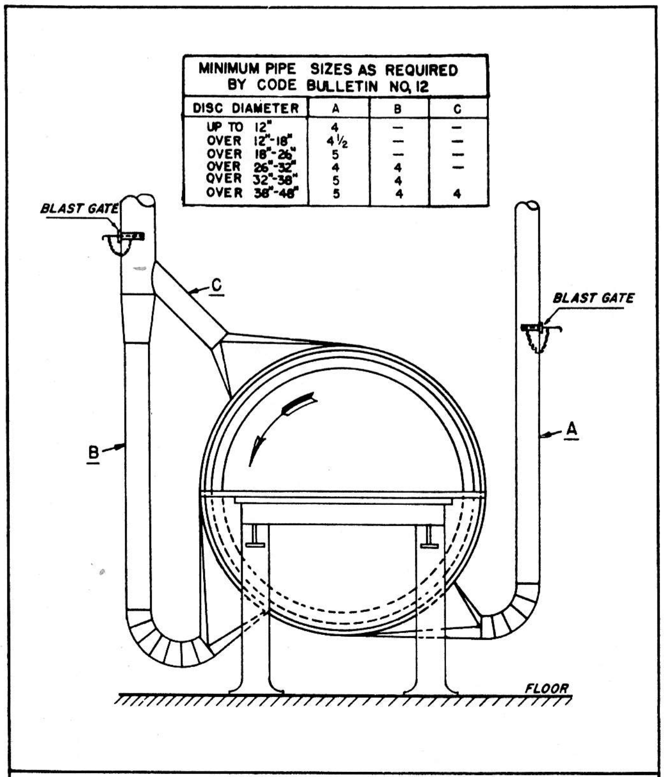
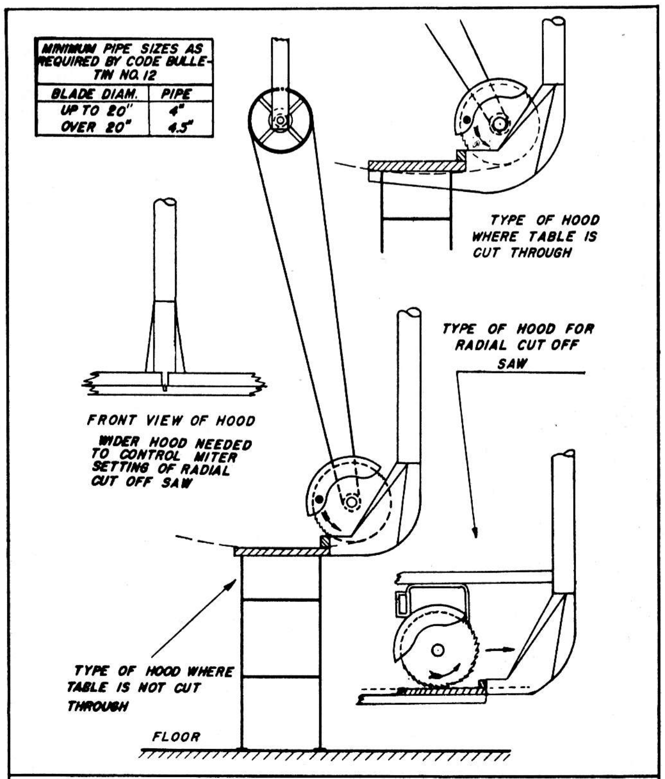


MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12			
DISC DIAMETER	A	B	C
UP TO 12"	4	—	—
OVER 12"-18"	4½	—	—
OVER 18"-26"	5	—	—
OVER 26"-32"	4	4	—
OVER 32"-38"	5	4	
OVER 38"-48"	5	4	4

DISC SANDER



MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12	
BLADE DIAM.	PIPE
UP TO 20"	4"
OVER 20"	4.5"

TYPE OF HOOD WHERE TABLE IS CUT THROUGH
TYPE OF HOOD FOR RADIAL CUT OFF SAW
FRONT VIEW OF HOOD
WIDER HOOD NEEDED TO CONTROL MITER SETTING OF RADIAL CUT OFF SAW
TYPE OF HOOD WHERE TABLE IS NOT CUT THROUGH
FLOOR

SWING OR RADIAL CUT OFF SAW

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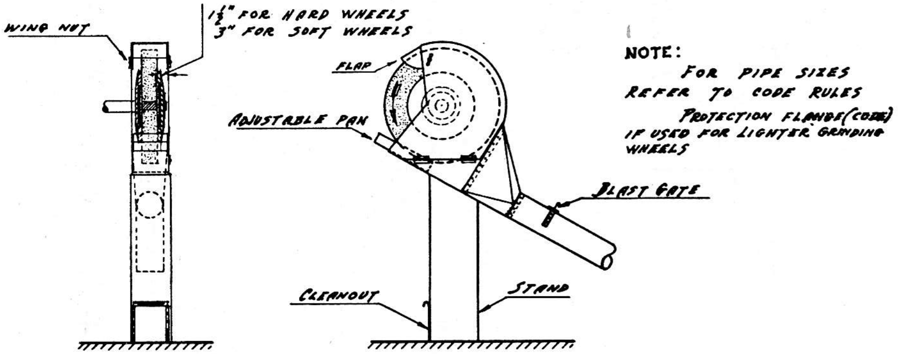
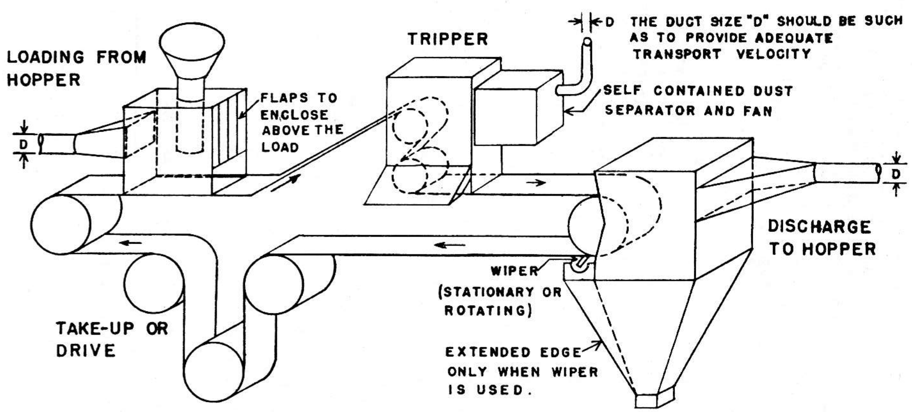


NOTE:
FOR PIPE SIZES REFER TO CODE RULES
PROTECTION FLANGE (CODE) IF USED FOR LIGHTER GRINDING WHEELS

POLISHING AND BUFFING HOOD


LOADING FROM HOPPER
D
FLAPS TO ENCLOSE ABOVE THE LOAD
TRIPPER
D
THE DUCT SIZE "D" SHOULD BE SUCH AS TO PROVIDE ADEQUATE TRANSPORT VELOCITY
SELF CONTAINED DUST SEPARATOR AND FAN
D
DISCHARGE TO HOPPER
WIPER (STATIONARY OR ROTATING)
TAKE-UP OR DRIVE
EXTENDED EDGE ONLY WHEN WIPER IS USED.

MINIMUM VENTILATION RATE			
BELT SPEED FPM		UNDER 200	OVER 200
CFM PER FOOT OF BELT WIDTH	WHICHEVER IS GREATER	350	500
LFM THROUGH NET OPEN AREA		150[2]	200

1. THE TAKE-UP OR DRIVE SHOULD BE ENCLOSED AND VENTILATED IF CONDITION WARRANTS.
2. THE MINIMUM VENTILATION RATE FOR STONE CRUSHING OPERATIONS IS 200 LFM THRU THE NET OPEN AREA.
3. FOR LOADING FROM AND TO BUCKET ELEVATORS REFER TO PLATE NO. 154.

BELT CONVEYOR

MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12	
BLADE DIAMETER	PIPE SIZE
UP TO 16"	4"
OVER 16"-24"	4.5"
OVER 24"	5"

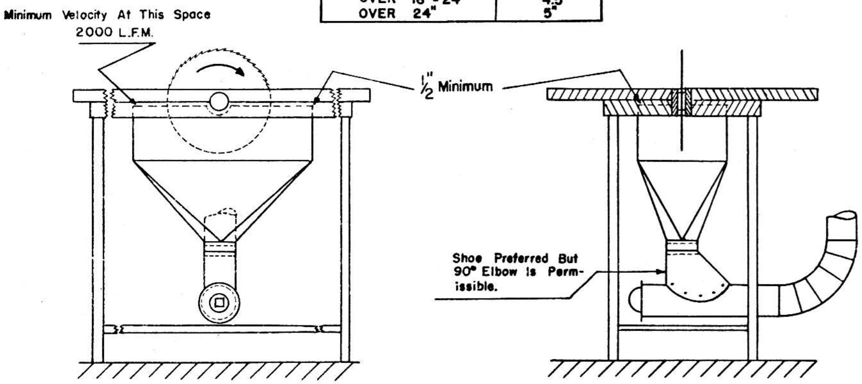
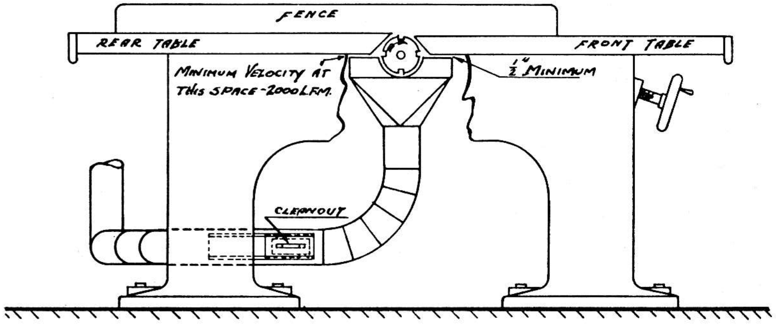

Minimum Velocity At This Space 2000 L.F.M.
½" Minimum
Shoe Preferred But 90° Elbow Is Permissible.

TABLE SAW

MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12	
KNIFE SIZE	DIAMETER
UP TO 6"	4"
OVER 6"-12"	4.5"
OVER 12"-20"	5"
OVER 20"	6"



JOINTER

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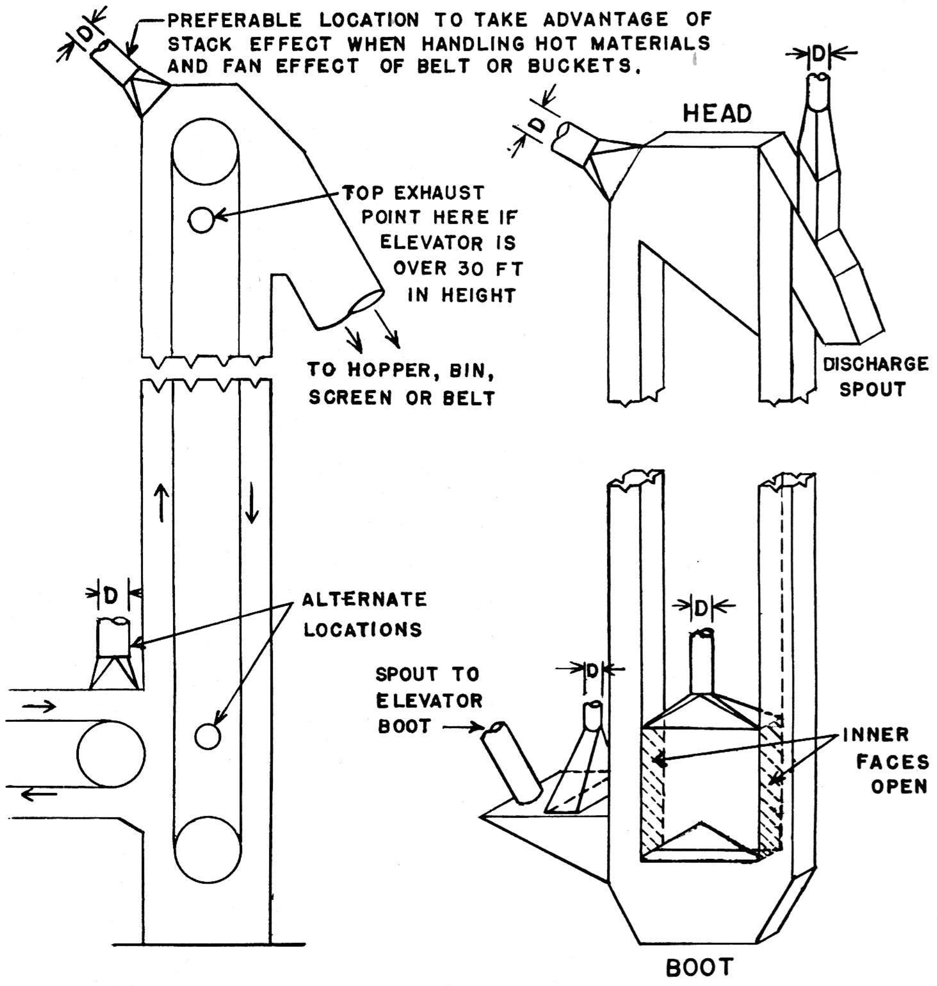

PREFERABLE LOCATION TO TAKE ADVANTAGE OF STACK EFFECT WHEN HANDLING HOT MATERIALS AND FAN EFFECT OF BELT OR BUCKETS.
D
TOP EXHAUST POINT HERE IF ELEVATOR IS OVER 30 FT IN HEIGHT
TO HOPPER, BIN, SCREEN OR BELT
HEAD
D
D
DISCHARGE SPOUT
D
ALTERNATE LOCATIONS
SPOUT TO ELEVATOR BOOT
D
D
INNER FACES OPEN
BOOT

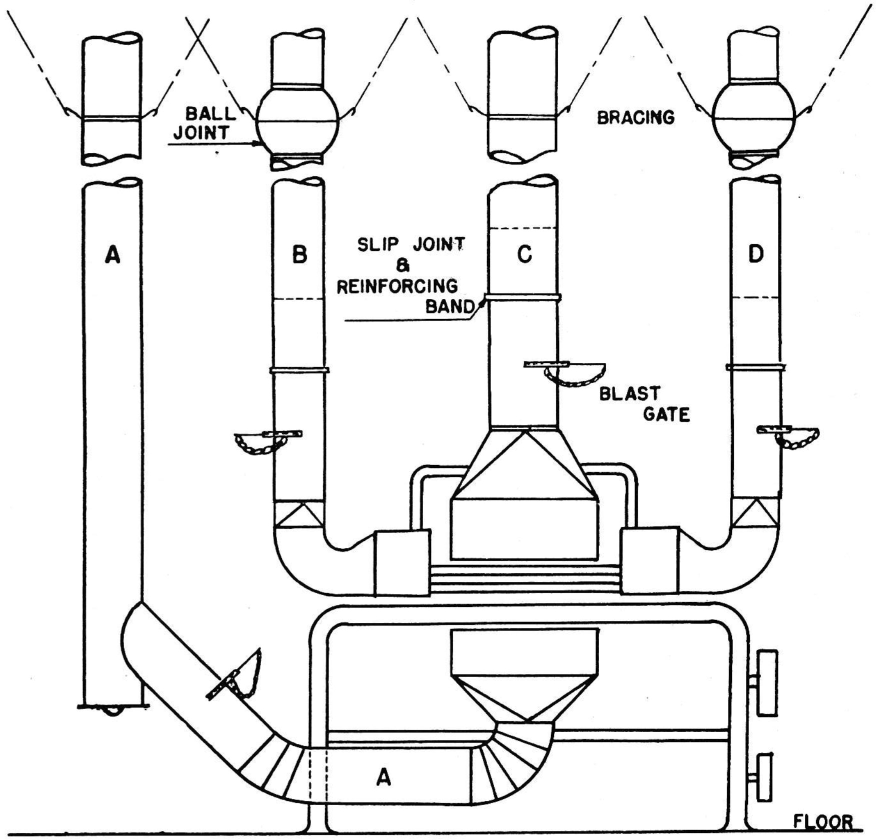
THE MINIMUM VENTILATION RATE SHOULD BE 150 LFM (EXCEPT IN STONE CRUSHING OPERATIONS WHERE THE MINIMUM IS 200 LFM) THRU THE NET OPEN AREA. THE DUCT SIZE "D" SHOULD BE SUCH AS TO PROVIDE ADEQUATE TRANSPORT VELOCITY.

BUCKET ELEVATOR

FROM DEPT. OF LABOR, STATE OF NEW YORK. USED BY PERMISSION

MINIMUM PIPE SIZES AS REQUIRED BY CODE BULLETIN NO. 12

MOULDER SIZE	PIPE SIZES		
	A	B,D	C
UP TO 7"	4.5"	4"	5"
OVER 7"-12"	5"	4.5"	6"
OVER 12"-18"	6"	5"	7"
OVER 18"-24"	7"	6"	8"
OVER 24"	8"	7"-8"	9"



MOULDER

FROM DEPT. OF LABOR, STATE OF NEW YORK. USED BY PERMISSION

TABLE No. 1

SIZE OF PHELPS FANS RECOMMENDED FOR VARIOUS MAIN DISCHARGE PIPES*

Model or No. of Fan		Pipe Size for Fan
No. 18M		7" Diameter
No. 20L		8" “
No. 25K		10" “
Model "H" —	30"	11" “
And "HV-1"	35"	12" “
	40"	13" “
	45"	15" “
	50"	17" “
Model "R" —	50"	18" “
And "RV-1"	54"	19" “
	58"	20" “
	62"	21" “
Model	WO-451	26" “
	WO-505	29" “
	WO-575	33" “
	WO-643	37" “
	WO-712	41" “
	WO-782	45" “

*Note: For pipe sizes not shown use next larger fan size.

TABLE No. 2

MINIMUM SIZES OF BRANCH PIPES FOR VARIOUS SIZES OF GRINDING AND POLISHING WHEELS*

(Abrasive Wheels)

Diameter of Wheel	Maximum Wheel Surface (Sq. Inches)	Minimum Pipe Diameter (Inches)
6" or less—Not over 1" thick	19	3
Over 6" to 9" Inc.—Not over 1½" thick	43	3½
Over 9" to 16" Inc.—Not over 2" thick	101	4
Over 16" to 19" Inc.—Not over 3" thick	180	4½
Over 19" to 24" Inc.—Not over 4" thick	302	5
Over 24" to 30" Inc.—Not over 5" thick	472	6

Where the maximum grinding surface exceeds 472 Sq. Inches a proportion of one square inch of pipe area to each 15 square inches of grinding surface shall be provided for dust removal.

Disc Wheels: 24" Diameter or less require a 4¼" Diam. Pipe.
Over 24" Diameter require a 5" Diam. Pipe.

TABLE No. 3

MINIMUM SIZES OF BRANCH PIPES FOR VARIOUS SIZES OF BUFFING WHEELS*

Diameter of Wheel	Maximum Wheel Surface (Sq. Inches)	Minimum Pipe Diameter (Inches)
6" or less—Not over 1" thick	19	3½
Over 6" to 12" Inc.—Not over 2" thick	75	4
Over 12" to 16" Inc.—Not over 3" thick	151	4½
Over 16" to 20" Inc.—Not over 4" thick	251	5
Over 20" to 24" Inc.—Not over 5" thick	377	5½
Over 24" to 30" Inc.—Not over 6" thick	565	6½

If a wheel is thicker than given in the above table it shall have branch pipes not smaller than is called for by its wheel surface as specified above.

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*From Dept. of Labor, State of New York. Used by Permission

TABLE No. 4

RECOMMENDED PIPE SIZES FOR VARIOUS WOODWORKING MACHINES*

(Pipe dimensions are diameters of round pipe)

SELF FEED TABLE RIP SAW

Up to 16" Diam.	4½" Pipe on bottom — 4" Pipe on top
Over 16" Diam.	5" Pipe on bottom — 4" Pipe on top

LARGE SELF FEED RIP SAWS OTHER THAN TABLE SAWS — Wet lumber 6" Pipe on bottom — 5" Pipe on top

SWING SAWS — Up to 20" Diam. 4" Pipe   Over 20" Diam. 4½" Pipe

ALL RIP SAWS, TABLE SAWS, MITRE SAWS AND VARIETY SAWS

Up to 16" Diam.	4" Pipe
Over 16" Diam. to 24" Diam.	4½" Pipe
Over 24" Diam.	5" Pipe
Variety Saw with Dado head	5" Pipe

GANG RIP SAWS

Up to 24" Diam.	5" Pipe on bottom — 4" Pipe on top
Over 24" to 36" Diam.	6" Pipe on bottom — 4½" Pipe on top
Over 36" to 48" Diam.	7" Pipe on bottom — 5" Pipe on top
Over 48" Diam.	8" Pipe on bottom — 5½" Pipe on top

DISC SANDERS

Up to 12" Diam.	4" Pipe
Over 12" to 18" Diam.	4½" Pipe
Over 18" to 26" Diam.	5" Pipe
Over 26" to 32" Diam.	Two 4" Pipes
Over 32" to 38" Diam.	One 4" Pipe and One 5" Pipe
Over 38" to 48" Diam.	One 5" Pipe and Two 4" Pipes

TRIPLE DRUM SANDERS

Less than 30" long	7" Pipe
30" to 36" long	8" Pipe
Over 36" to 42" long	9" Pipe
Over 42" to 48" long	10" Pipe
Over 48" long	11" Pipe

SINGLE DRUM SANDERS

Up to 10" Diam. and not more than 200 Sq. In. of working surface	4" Pipe
Over 10" Diam. and not more than 400 Sq. In. of working surface	4½" Pipe
Over 400 Sq. In. of working surface and not over 700 Sq. In.	5" Pipe
Over 700 Sq. In. of working surface and not over 1400 Sq. In.	6" Pipe
Over 1400 Sq. In. of working surface and not over 2400 Sq. In.	7" Pipe

Note: On long drums of small diameter, sizes mentioned above should be divided into two or more pipes equalling in area that of single pipe allowed for working surface.

HORIZONTAL BELT SANDERS

Where bottom run of belt is used.

Less than 6" in width	4½" Pipe on bottom — 4" Pipe on top
6" to 9" in width	5" Pipe on bottom — 4" Pipe on top
Over 9" to 14" in width	6" Pipe on bottom — 4½" Pipe on top
Over 14" in width	7" Pipe on bottom — 5" Pipe on top

Where top run of belt is used.

Where top run of belt is used, pipe on top is not necessary on flat work, but where other work is done a telescopic pipe conforming to above dimensions, with hood, should be installed above the work.

VERTICAL BELT SANDER — With rear belt and both pulleys enclosed.

Less than 6" in width	4½" Pipe on bottom
6" to 9" in width	5" Pipe on bottom
Over 9" to 14" in width	6" Pipe on bottom
Over 14" in width	7" Pipe on bottom

SWING ARM SANDER—POST OR COLUMN SANDER — One 4" Diam. pipe divided into two 3" Diam. pipes.

BAND SAWS

Blade under 2" in width	Two pipes each at least 4" Diam. One with hood on front of saw and the other at a point near the floor on the uprun side of lower wheel. The entire lower wheel shall be enclosed to form a hood.

BAND RESAWS

	Down Run	Up Run
Blade 2" to 3" in width	5" Diam. Pipe	4" Diam. Pipe
Blade over 3" to 4" in width	6" Diam. Pipe	5" Diam. Pipe
Blade over 4" to 6" in width	7" Diam. Pipe	5" Diam. Pipe
Blade over 6" to 8" in width	8" Diam. Pipe	5" Diam. Pipe

JOINTERS

Up to 6" Knives	4" Diam. Pipe
Over 6" to 12" Knives	4½" Diam. Pipe
Over 12" to 20" Knives	5" Diam. Pipe
Over 20" Knives	6" Diam. Pipe

SINGLE PLANERS

Up to 20" Knives	5" Diam. Pipe
Over 20" to 26" Knives	6" Diam. Pipe
Over 26" to 36" Knives	7" Diam. Pipe
Over 36" Knives	8" Diam. Pipe

DOUBLE PLANERS

	On Top Head	On Bottom Head
Up to 20" Knives	5" Diam. Pipe	5" Diam. Pipe
Over 20" to 26" Knives	6" Diam. Pipe	5" Diam. Pipe
Over 26" to 36" Knives	7" Diam. Pipe	6" Diam. Pipe
Over 36" Knives	8" Diam. Pipe	7" Diam. Pipe

MOULDERS, MATCHERS, SIZERS

Size	Top Head	Bottom Head	Right	Left
Up to 7"	5" Diam. Pipe	4½" Diam. Pipe	4" Diam. Pipe	4" Diam. Pipe
Over 7" to 12"	6" Diam. Pipe	5" Diam. Pipe	4½" Diam. Pipe	4½" Diam. Pipe
Over 12" to 18"	7" Diam. Pipe	6" Diam. Pipe	5" Diam. Pipe	5" Diam. Pipe
Over 18" to 24"	8" Diam. Pipe	7" Diam. Pipe	6" Diam. Pipe	6" Diam. Pipe
Over 24"	9" Diam. Pipe	8" Diam. Pipe	7" to 8" Diam. Pipe	7" to 8" Diam. Pipe

SASH STICKERS — 4" Diam. pipe on each head.

WOODSHAPERS AND VARIETY MACHINES — One pipe 4½" Diam. to 6" Diam. for each spindle according to size and character of work.

TENONER — Top Head 5" Diam. Pipe   Bottom Head 5" Diam. Pipe   Other Heads 4½" to 5" Diam. Pipes
Where saws are used 4" Diam. Pipe on each saw.

AUTOMATIC LATHES 3" Diam. Pipe to 10" Diam. Pipe according to length

FORMING LATHES	4" Diam. Pipe
CHAIN MORTISES	3" Diam. Pipe
DOVE TAIL AND LOCK CORNER MACHINES	4" Diam. Pipe
PULLEY POCKETS	5" Diam. Pipe
PULLEY STILES	5" Diam. Pipe
GLUE JOINTERS	6" Diam. Pipe
PLOUGHS	4" Diam. Pipe
HOGS — Up to 12" wide	8" Diam. Pipe
DOWEL MACHINES	4" Diam. Pipe
PANEL RAISERS	4" Diam. Pipe on each head
RALISHERS	4" Diam. Pipe
GAINERS	4" Diam. Pipe
ROUTERS	4" Diam. Pipe
DUPLEX MOULDING SANDERS	4" Diam. Pipe
Over 12" wide	12" Diam. Pipe

FLOOR SWEEPS — 6" Diam. Pipe for fine dust to 8" Diam. Pipe for coarse material. Mouth at floor, 10" x 4" to 12" x 5".

Note: The area of floor sweep pipes need not be included in computing main pipe areas.

*Reprinted with permission of State of New York Dept. of Labor, Board of Standards and Appeals, Industrial Code Rule No. 12.

TABLE No. 5

VELOCITIES REQUIRED FOR PNEUMATIC CONVEYING*

Material	Velocity F.P.M. From	Velocity F.P.M. To
Wood flour	4000	6000
Sawdust	4000	6000
Hog waste	4500	6500
Pulp chips	4500	7000
Tanbark, dry	4500	7000
Tanbark, leached, damp	5500	7500
Cork, ground	3500	5500
Metal turnings	5000	7000
Cotton	4000	6000
Wool	4500	6000
Jute	4500	6000
Hemp	4500	6000
Rags	4500	6500
Cotton seed	4000	6000
Flour	3500	6000
Oats	4500	6000
Barley	5000	6500
Corn	5000	7000
Wheat	5000	7000
Rye	5000	7000
Coffee beans, stoned	3000	3500
Coffee beans, unstoned	3500	4000
Sugar	5000	6000
Salt	5500	7500
Coal, powdered	4000	5500
Ashes, clinkers, ground	6000	8500
Lime	5000	7000
Cement, portland	6000	9000
Sand	6000	9000

Dense materials require less air per pound than do lighter and bulkier substances. From 35 to 50 cu. ft. of air per pound should handle any material in Table No. 5 at the lower velocity quoted. It is probable that 15 to 20 cu. ft. of air per pound of material is sufficient for the upper velocities listed. Mechanical feeds may reduce these values somewhat if conditions are favorable.

The weight of conveyed material per cubic foot of air varies with the square of the velocity.

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*Used with permission "Design of Industrial Exhaust Systems," by John L. Alden—The Industrial Press, Third Edition.

TABLE No. 6

VELOCITY PRESSURES FOR DIFFERENT VELOCITIES

[Velocity (V) in feet per minute and Velocity Pressure (VP) in inches of water]

$$VP = \left(\frac{V}{4005}\right)^2 \qquad 4005\sqrt{VP} = V$$

VP	*V*	*VP*	*V*	*VP*	*V*	*VP*	*V*	*VP*	*V*	*VP*	*V*
0.06	981	0.53	2916	1.00	4005	1.47	4856	1.94	5579	3.00	6937
0.07	1060	0.54	2943	1.01	4025	1.48	4873	1.95	5593	3.05	6994
0.08	1133	0.55	2970	1.02	4045	1.49	4889	1.96	5608	3.10	7052
0.09	1201	0.56	2997	1.03	4064	1.50	4905	1.97	5623	3.15	7108
0.10	1266	0.57	3024	1.04	4084	1.51	4921	1.98	5637	3.20	7164
0.11	1328	0.58	3050	1.05	4103	1.52	4938	1.99	5651	3.25	7220
0.12	1387	0.59	3076	1.06	4123	1.53	4954	2.00	5664	3.30	7275
0.13	1444	0.60	3102	1.07	4142	1.54	4970	2.01	5678	3.35	7330
0.14	1498	0.61	3127	1.08	4162	1.55	4986	2.02	5692	3.40	7385
0.15	1551	0.62	3153	1.09	4181	1.56	5002	2.03	5706	3.45	7439
0.16	1602	0.63	3179	1.10	4200	1.57	5018	2.04	5720	3.50	7493
0.17	1651	0.64	3204	1.11	4219	1.58	5034	2.05	5734	3.55	7546
0.18	1699	0.65	3229	1.12	4238	1.59	5050	2.06	5748	3.60	7599
0.19	1746	0.66	3254	1.13	4257	1.60	5066	2.07	5762	3.65	7652
0.20	1791	0.67	3279	1.14	4276	1.61	5082	2.08	5776	3.70	7704
0.21	1835	0.68	3303	1.15	4295	1.62	5098	2.09	5790	3.75	7756
0.22	1879	0.69	3327	1.16	4314	1.63	5114	2.10	5804	3.80	7807
0.23	1921	0.70	3351	1.17	4332	1.64	5129	2.11	5817	3.85	7858
0.24	1962	0.71	3375	1.18	4350	1.65	5144	2.12	5831	3.90	7909
0.25	2003	0.72	3398	1.19	4368	1.66	5160	2.13	5845	3.95	7960
0.26	2042	0.73	3422	1.20	4386	1.67	5175	2.14	5859	4.00	8010
0.27	2081	0.74	3445	1.21	4405	1.68	5191	2.15	5872	4.05	8060
0.28	2119	0.75	3468	1.22	4423	1.69	5206	2.16	5886	4.10	8110
0.29	2157	0.76	3491	1.23	4442	1.70	5222	2.17	5899	4.15	8159
0.30	2193	0.77	3514	1.24	4460	1.71	5237	2.18	5913	4.20	8208
0.31	2230	0.78	3537	1.25	4478	1.72	5253	2.19	5927	4.25	8257
0.32	2260	0.79	3560	1.26	4495	1.73	5268	2.20	5940	4.30	8305
0.33	2301	0.80	3582	1.27	4513	1.74	5283	2.21	5954	4.35	8353
0.34	2335	0.81	3604	1.28	4531	1.75	5298	2.22	5967	4.40	8400
0.35	2369	0.82	3625	1.29	4549	1.76	5313	2.23	5981	4.45	8449
0.36	2403	0.83	3657	1.30	4566	1.77	5328	2.24	5994	4.50	8496
0.37	2436	0.84	3669	1.31	4583	1.78	5343	2.25	6008	4.55	8543
0.38	2469	0.85	3690	1.32	4601	1.79	5359	2.30	6074	4.60	8590
0.39	2501	0.86	3709	1.33	4619	1.80	5374	2.35	6140	4.65	8636
0.40	2533	0.87	3729	1.34	4636	1.81	5388	2.40	6205	4.70	8683
0.41	2563	0.88	3758	1.35	4653	1.82	5403	2.45	6269	4.75	8729
0.42	2595	0.89	3779	1.36	4671	1.83	5418	2.50	6332	4.80	8775
0.43	2626	0.90	3800	1.37	4688	1.84	5433	2.55	6395	4.85	8820
0.44	2656	0.91	3821	1.38	4705	1.85	5447	2.60	6458	4.90	8865
0.45	2687	0.92	3842	1.39	4722	1.86	5462	2.65	6520	4.95	8910
0.46	2716	0.93	3863	1.40	4739	1.87	5477	2.70	6581	5.00	8955
0.47	2746	0.94	3884	1.41	4756	1.88	5491	2.75	6642	5.05	9000
0.48	2775	0.95	3904	1.42	4773	1.89	5506	2.80	6702		
0.49	2804	0.96	3924	1.43	4790	1.90	5521	2.85	6761		
0.50	2832	0.97	3945	1.44	4806	1.91	5535	2.90	6820		
0.51	2860	0.98	3965	1.45	4823	1.92	5550	2.95	6879		
0.52	2888	0.99	3985	1.46	4840	1.93	5564				

CORRECTING FAN PERFORMANCE AT ALTITUDES OTHER THAN NEAR SEA LEVEL AND AT TEMPERATURES OTHER THAN 70° F.

FOR ALTITUDES

Multiply the static pressures and actual horsepowers as shown in the performance chart at a selected fan speed by the altitude density factor shown in table 7 at the required feet altitude. The result will be the fan capacity at the new altitude.

FOR TEMPERATURES

Multiply the static pressures and actual horsepowers as shown in the performance chart at a selected fan speed by the temperature density factor shown in the table 8 at the required temperature. The result will be the fan capacity at the new temperature.

FOR BOTH ALTITUDE AND TEMPERATURE COMBINED

Multiply the altitude density factor at the required feet altitude (table 7) by the temperature density factor at the required temperature (table 8) to find the composite factor. Multiply this composite factor by the static pressures and actual horsepowers at the selected fan speed in the performance chart. The result will be the new fan capacity at the new altitude and the new temperature.

EXAMPLE: Required—Fan to handle 6000 CFM at 5" Static Pressure and at 7000' Altitude and 300° Temperature F.

1. Temperature Density factor at 300° F. Temp. is .697 (Table 8).
2. Altitude density factor at 7000' Alt. is .766 (Table 7).
3. .697 × .766 equals .534 — Composite Factor.
4. Divide this composite factor into the required static pressure: 5" ÷ .534 = 9.36" S.P.
5. We now look for a fan which will produce the required 6000 CFM at a static pressure of 9.36". From the performance data charts it is found that a 35" Model "H" fan operating at 1662 RPM will produce 6120 CFM at 10" S.P. and with 19.5 Horsepower, at near sea level and at 70° F. Temp. We now have that line of data in the performance chart which, when corrected to the required Altitude and Temperature, will give us the fan requirements for the original problem. Only the Static Pressure and the Horsepower will vary with the density change. Therefore
6. .534 × 10" S.P. equals 5.34" S.P.
7. .534 × 19.5 H.P. equals 10.41 H.P.

   The final performance of the 35" Model "H" fan for this altitude and temperature requirement is 6120 CFM at 5.34" S.P. with 10.41 actual horsepower at a fan speed of 1662 RPM.

By multiplying the composite factor (.534) by each static pressure and actual horsepower figure as shown at this fan speed in the performance chart the entire fan capacity range at this speed can be found for this temperature and altitude.

TABLE No. 7
ALTITUDE-DENSITY TABLE FOR AIR
STANDARD AIR AT O ALT. (29.92" BAR.) = 1.

Alt. Ft.	Dens. Fact.	Alt. Ft.	Dens. Fact.	Alt. Ft.	Dens. Fact.	Alt. Ft.	Dens. Fact.
0	1.00	1500	.944	3000	.891	6000	.795
100	.996	1600	.941	3200	.885	6200	.789
200	.992	1700	.937	3400	.878	6400	.784
300	.989	1800	.933	3600	.872	6600	.778
400	.985	1900	.930	3800	.865	6800	.772
500	.981	2000	.926	4000	.858	7000	.766
600	.977	2100	.923	4200	.852	7200	.760
700	.974	2200	.919	4400	.846	7400	.754
800	.970	2300	.916	4600	.839	7600	.748
900	.966	2400	.912	4800	.833	7800	.743
1000	.962	2500	.909	5000	.826	8000	.737
1100	.959	2600	.905	5200	.820	8200	.731
1200	.955	2700	.902	5400	.814	8400	.726
1300	.952	2800	.898	5600	.808	8600	.720
1400	.948	2900	.895	5800	.802	8800	.714

TABLE No. 8
TEMPERATURE-DENSITY TABLE FOR AIR
STANDARD AIR = 70° F. = 1.

Temp. F.	Dens. Fact.	Temp. F.	Dens. Fact.	Temp. F.	Dens. Fact.	Temp. F.	Dens. Fact.	Temp. F.	Dens. Fact.
−10	1.178	60	1.019	100	.946	200	.803	400	.616
− 5	1.165	62	1.015	105	.938	210	.791	425	.599
0	1.152	64	1.011	110	.930	220	.779	450	.582
5	1.140	66	1.008	115	.922	230	.768	475	.567
10	1.128	68	1.004	120	.914	240	.757	500	.552
15	1.116	70	1.000	125	.906	250	.747	525	.538
20	1.104	72	.996	130	.898	260	.736	550	.525
25	1.093	74	.992	135	.891	270	.726	575	.512
30	1.082	76	.989	140	.883	280	.716	600	.500
35	1.071	78	.985	145	.876	290	.707	625	.488
40	1.060	80	.982	150	.869	300	.697	650	.477
42	1.056	82	.978	155	.862	310	.688	675	.467
44	1.052	84	.974	160	.855	320	.680	700	.457
46	1.047	86	.971	165	.848	330	.671	725	.447
48	1.043	88	.967	170	.841	340	.662	750	.438
50	1.039	90	.964	175	.835	350	.654	775	.429
52	1.035	92	.960	180	.828	360	.646	800	.421
54	1.031	94	.957	185	.822	370	.638	825	.412
56	1.027	96	.953	190	.815	380	.631	850	.404
58	1.023	98	.950	195	.809	390	.624	875	.397

TABLE No. 9

TABLE OF AREA AND CIRCUMFERENCE OF CIRCLES

Diam. in In.	Area		Circumference	
	Sq. In.	Sq. Ft.	In.	Ft.
¼	0.049	.0003	0.785	.0652
½	0.196	.0014	1.571	.1309
¾	0.442	.0031	2.356	.1964
1	0.785	.0054	3.142	.2618
1¼	1.227	.0085	3.927	.3273
1½	1.767	.0123	4.712	.3927
1¾	2.405	.0167	5.498	.4582
2	3.142	.0218	6.283	.5236
2¼	3.976	.0276	7.069	.5891
2½	4.909	.0341	7.854	.6546
2¾	5.939	.0412	8.639	.7200
3	7.069	.0491	9.425	.7854
3¼	8.296	.0576	10.21	.8510
3½	9.621	.0668	10.99	.9160
3¾	11.04	.0767	11.78	.9818
4	12.57	.0873	12.57	1.047
4¼	14.19	.0986	13.35	1.113
4½	15.90	.1104	14.14	1.178
4¾	17.72	.1231	14.92	1.243
5	19.64	.1364	15.71	1.309
5¼	21.65	.1504	16.49	1.374
5½	23.76	.1650	17.28	1.440
5¾	25.97	.1840	18.06	1.505
6	28.27	.1964	18.85	1.571
6¼	30.68	.2131	19.64	1.637
6½	33.18	.2304	20.42	1.702
6¾	35.79	.2486	21.21	1.768
7	38.49	.2673	21.99	1.833
7¼	41.28	.2867	22.78	1.899
7½	44.18	.3068	23.56	1.964
7¾	47.17	.3276	24.35	2.029
8	50.27	.3491	25.13	2.094
8¼	53.46	.3713	25.92	2.160
8½	56.75	.3942	26.70	2.225
8¾	60.13	.4175	27.49	2.291
9	63.62	.4418	28.27	2.356
9¼	67.20	.4668	29.06	2.422
9½	70.88	.4923	29.85	2.488
9¾	74.66	.5185	30.63	2.553
10	78.54	.5454	31.42	2.618
10½	86.59	.6010	32.99	2.750
11	95.03	.6600	34.56	2.880
11½	103.9	.7215	36.13	3.011
12	113.1	.7854	37.70	3.142
12½	122.7	.8520	39.27	3.273
13	132.7	.9218	40.84	3.403
13½	143.1	.9937	42.41	3.535
14	153.9	1.069	43.98	3.665
14½	165.1	1.146	45.55	3.796
15	176.7	1.227	47.12	3.927
15½	188.7	1.310	48.69	4.058
16	201.1	1.396	50.27	4.189
16½	213.8	1.485	51.84	4.321
17	226.9	1.576	53.41	4.451
17½	240.5	1.670	54.98	4.582
18	254.5	1.767	56.55	4.712
18½	268.8	1.867	58.12	4.845
19	283.5	1.969	59.69	4.974
19½	298.6	2.074	61.26	5.105
20	314.2	2.182	62.83	5.236
20½	330.1	2.293	64.40	5.367
21	346.4	2.405	65.97	5.498
21½	361.1	2.508	67.54	5.629
22	380.1	2.640	69.12	5.760
22½	397.6	2.761	70.69	5.891
23	415.5	2.885	72.26	6.021
23½	433.7	3.012	73.83	6.153
24	452.4	3.142	75.40	6.283
24½	471.4	3.274	76.97	6.415
25	490.9	3.409	78.54	6.545
25½	510.7	3.547	80.11	6.676
26	530.9	3.687	81.68	6.807
26½	551.6	3.832	83.25	6.938
27	572.6	3.976	84.82	7.069
27½	593.9	4.125	86.39	7.199
28	615.8	4.276	87.97	7.330
28½	637.9	4.430	89.54	7.462
29	660.52	4.587	91.11	7.592
29½	683.5	4.747	92.63	7.725
30	706.8	4.909	94.25	7.854
31	754.8	5.241	97.39	8.116
32	804.3	5.585	100.5	8.378
33	855.3	5.940	103.7	8.639
34	907.9	6.305	106.8	8.901
35	962.1	6.681	109.9	9.163
36	1018	7.069	113.1	9.425
37	1075	7.467	116.2	9.686
38	1134	7.876	119.4	9.948
39	1195	8.296	122.5	10.21
40	1256	8.727	125.6	10.47
41	1320	9.168	128.8	10.73
42	1385	9.621	131.9	10.99
43	1452	10.08	135.1	11.26
44	1521	10.56	138.2	11.52
45	1590	11.04	141.4	11.78
46	1662	11.54	144.5	12.04
47	1735	12.05	147.7	12.30
48	1810	12.51	150.8	12.57
49	1886	13.09	153.9	12.83
50	1963	13.64	157.1	13.09
51	2043	14.19	160.2	13.35
52	2124	14.75	163.4	13.61
53	2206	15.32	166.5	13.88
54	2290	15.90	169.6	14.14
55	2376	16.50	172.8	14.40
56	2463	17.10	175.9	14.66
57	2552	17.72	179.1	14.92
58	2642	18.35	182.2	15.18
59	2734	18.99	185.4	15.45
60	2827	19.63	188.5	15.71
61	2922	20.29	191.6	15.97
62	3019	20.97	194.8	16.23
63	3117	21.65	197.9	16.49
64	3217	22.34	201.1	16.76
65	3318	23.04	204.2	17.02
66	3421	23.76	207.3	17.28
67	3526	24.48	210.5	17.54
68	3632	25.22	213.6	17.80
69	3739	25.97	216.8	18.06
70	3848	26.73	219.9	18.33
71	3959	27.49	223.1	18.59
72	4072	28.27	226.2	18.85
73	4185	29.07	229.3	19.11
74	4301	29.87	232.5	19.37
75	4418	30.68	235.6	19.63
76	4536	31.50	238.8	19.90
77	4657	32.34	241.9	20.16
78	4778	33.18	245.0	20.42
79	4902	34.04	248.2	20.68
80	5027	34.91	251.3	20.94
81	5153	35.78	254.5	21.21
82	5281	36.67	257.6	21.47
83	5411	37.57	260.8	21.73
84	5542	38.48	263.9	21.99
85	5675	39.41	267.0	22.25
86	5809	40.34	270.2	22.51
87	5945	41.28	273.3	22.78
88	6082	42.24	276.5	23.04
89	6221	43.20	279.6	23.30
90	6362	44.18	282.7	23.56
91	6504	45.17	285.9	23.82
92	6648	46.16	289.0	24.09
93	6793	47.17	292.2	24.35
94	6940	48.19	295.3	24.61
95	7088	49.22	298.4	24.87
96	7238	50.27	301.6	25.13
97	7390	51.32	304.7	25.39
98	7543	52.38	307.9	25.66
99	7698	53.46	311.0	25.92
100	7854	54.54	314.2	26.18

CONSTRUCTION OF FANS FOR HANDLING AIR OR GASES AT ELEVATED TEMPERATURES

Up to 200°F. Temperature	Standard Construction
201° to 350°F. Temperature	Reflector shield between housing and front bearing.
351° to 800°F. Temperature	Shaft cooler wheel between front bearing and housing. Oil lubricated bearings-one fixed-one floating

At high temperatures, fan speeds are restricted to the following percentages of normal:

Temperature Deg. F	Percent of Normal Fan Speed
300°	95%
400°	90%
500°	85%
600°	80%
700°	75%
800°	65%

TABLE No. 10

Resistance of Round Elbows Expressed in Equivalent Length of Straight Pipe

Angle of bend—Round pipe with center line radius equal at least to twice its diam. and when followed by straight duct.	Multiply pipe diam. by this factor to obtain equivalent length of straight pipe.
15°	1.8
30°	3.4
45°	5.2
60°	6.8
75°	8.4
90°	10.0
120°	12.7
150°	15.0
180°	16.5

TABLE No. 11

CENTIGRADE-FAHRENHEIT CONVERSION TABLE

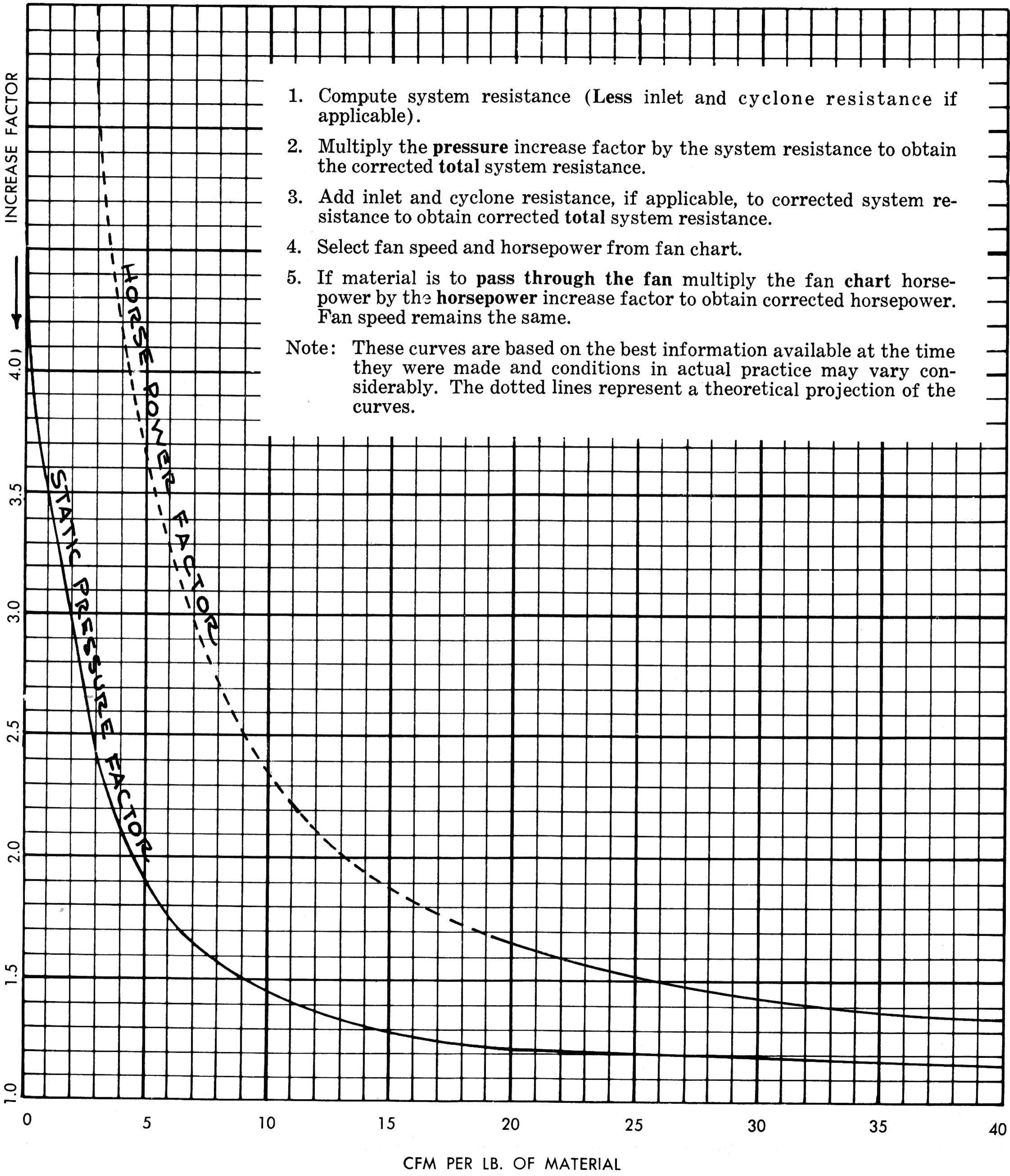
$F = 9/5\ C + 32 = 1.8\ (C + 17.8)$ $°C = 5/9\ (°F - 32)$

C. ←	F. ↓ C.	→ F.	C. ←	F. ↓ C.	→ F.
−62.2	−80	−112.0	101.7	215	419.0
−56.7	−70	− 94.0	104.4	220	428.0
−51.1	−60	− 76.0	107.2	225	437.0
−45.6	−50	− 58.0	110.0	230	446.0
−40.0	−40	− 40.0	112.8	235	455.0
−34.4	−30	− 22.0	115.6	240	464.0
−31.7	−25	− 13.0	118.3	245	473.0
−28.9	−20	− 4.0	121.1	250	482.0
−26.1	−15	5.0	126.7	260	500.0
−23.3	−10	14.0	132.2	270	518.0
−20.6	− 5	23.0	137.8	280	536.0
−17.8	0	32.0	143.3	290	554.0
−15.0	5	41.0	148.9	300	572.0
−12.2	10	50.0	154.4	310	590.0
− 9.4	15	59.0	160.0	320	608.0
− 6.7	20	68.0	165.6	330	626.0
− 3.9	25	77.0	171.1	340	644.0
− 1.1	30	86.0	176.7	350	662.0
1.7	35	95.0	182.2	360	680.0
4.4	40	104.0	187.8	370	698.0
7.2	45	113.0	193.3	380	716.0
10.0	50	122.0	198.9	390	734.0
12.8	55	131.0	204.4	400	752.0
15.6	60	140.0	210.0	410	770.0
18.3	65	149.0	215.6	420	788.0
21.1	70	158.0	221.1	430	806.0
23.9	75	167.0	226.7	440	824.0
26.7	80	176.0	232.2	450	842.0
29.4	85	185.0	237.8	460	860.0
32.2	90	194.0	243.3	470	878.0
35.0	95	203.0	248.9	480	896.0
37.8	100	212.0	254.4	490	914.0
40.6	105	221.0	260.0	500	932.0
43.3	110	230.0	265.6	510	950.0
46.1	115	239.0	271.1	520	968.0
48.9	120	248.0	276.7	530	986.0
51.7	125	257.0	282.2	540	1004.0
54.4	130	266.0	287.8	550	1022.0
57.2	135	275.0	293.3	560	1040.0
60.0	140	284.0	298.9	570	1058.0
62.8	145	293.0	304.4	580	1076.0
65.6	150	302.0	310.0	590	1090.0
68.3	155	311.0	315.6	600	1112.0
71.1	160	320.0	326.7	620	1148.0
73.9	165	329.0	337.8	640	1184.0
76.7	170	338.0	348.9	660	1220.0
79.4	175	347.0	360.0	680	1256.0
82.2	180	356.0	371.1	700	1292.0
85.0	185	365.0	382.2	720	1328.0
87.8	190	374.0	393.3	740	1364.0
90.6	195	383.0	404.4	760	1400.0
93.3	200	392.0	415.6	780	1436.0
96.1	205	401.0	426.7	800	1472.0
98.9	210	410.0	437.8	820	1508.0

To convert to Centigrade, read left; for Fahrenheit read right.

Figure No. 8

INCREASE FACTOR CHART FOR CONVEYING BULK MATERIALS



1. Compute system resistance (**Less** inlet and cyclone resistance if applicable).
2. Multiply the **pressure** increase factor by the system resistance to obtain the corrected **total** system resistance.
3. Add inlet and cyclone resistance, if applicable, to corrected system resistance to obtain corrected **total** system resistance.
4. Select fan speed and horsepower from fan chart.
5. If material is to **pass through the fan** multiply the fan **chart** horsepower by the **horsepower** increase factor to obtain corrected horsepower. Fan speed remains the same.

Note: These curves are based on the best information available at the time they were made and conditions in actual practice may vary considerably. The dotted lines represent a theoretical projection of the curves.

USEFUL FAN AND SYSTEM LAWS

When air density, temperature and piping system remains constant the following laws apply: (See Note*)

A. When fan speed changes:

1. CFM varies **directly** as the fan speed $\frac{CFMc}{CFM} = \frac{RPMc}{RPM}$
2. Static pressure varies as the **square** of the fan speed $\frac{SPc}{SP} = \left(\frac{RPMc}{RPM}\right)^2$
3. Horsepower varies as the **cube** of the fan speed $\frac{HPc}{HP} = \left(\frac{RPMc}{RPM}\right)^3$

B. When CFM varies:

1. RPM varies **directly** as the CFM $\frac{RPMc}{RPM} = \frac{CFMc}{CFM}$
2. Static pressure varies as the **square** of the CFM $\frac{SPc}{SP} = \left(\frac{CFMc}{CFM}\right)^2$
3. Horsepower varies as the **cube** of the CFM $\frac{HPc}{HP} = \left(\frac{CFMc}{CFM}\right)^3$

C. When fan size varies (same design) and operating at the same **Tip Speed** and all dimensions of fan varies proportionately to the wheel diameter—then:

1. CFM varies as the **square** of the wheel diameter $\frac{CFMc}{CFM} = \left(\frac{Diam.c}{Diam.}\right)^2$
2. H.P. varies as the **square** of the wheel diameter $\frac{HPc}{HP} = \left(\frac{Diam.c}{Diam.}\right)^2$
3. Static pressure and efficiency are the **same**

*NOTE: c—Denotes the new or desired value. In using any of the above sets of laws, when one value changes all of the other values also change according to their respective laws. For example if the fan speed changes then the CFM, static pressure and horsepower all change at the same time in accordance with their laws.

D. Generally, for a given pipe diameter, the material handling capacity increases as the cube of the air velocity. There may be, however, points of critical velocities where rapid changes take place and this ratio may not apply at all velocities.

E. The **weight** of conveyed material per **cubic foot of air** varies with the **square** of the velocity.

F. Velocities must be selected with consideration for the nature and subsequent use of the conveyed material. For example many types of material would depreciate when handled at high velocities.

The Following Approximate **Pounds** of Residue Will Result From the Production of **1,000 Board Feet** of Lumber:

	Circle Sawn **¼" Curf.**	**Band Sawn** **⅛"-$\frac{5}{32}$" Curf.**	**Bark**
Saw Dust—Green Yellow Pine	2,200 Lbs.	1,600 Lbs.	1,070 Lbs.
Saw Dust—Dry Yellow Pine	1,000 Lbs.	—	
Shavings—Dry Yellow Pine	800 Lbs.		
Saw Dust—Green Hardwood	2,400 Lbs.	1,750 Lbs.	

Note: These estimates are based on averages obtained from several Southern Lumber Mills and results will vary from Mill to Mill and with sizes and species of logs and with size of finished lumber. A particular Mill may be able to accumulate more accurate data through continuing experience.

A Properly Loaded Vehicle Should Contain the Following:

	Open Top Ry. Car 35′ L. 15½′ H.	**Ry. Box Car 50′ L.**	**Trailer Van 40′ L.**	**Wt. Per Cu. Ft.**
Dry Pine Shavings	50,000 Lbs.	30,500 Lbs.	28,000 Lbs.	15 Lbs.
Green Pine Sawdust	90,000 Lbs.	55,000 Lbs.	48,000 Lbs.	26 Lbs.

TABLE No. 12
Weights of Solids
Pounds Per Cubic Foot
(1.244 Cubic Feet Equals One Bushel)

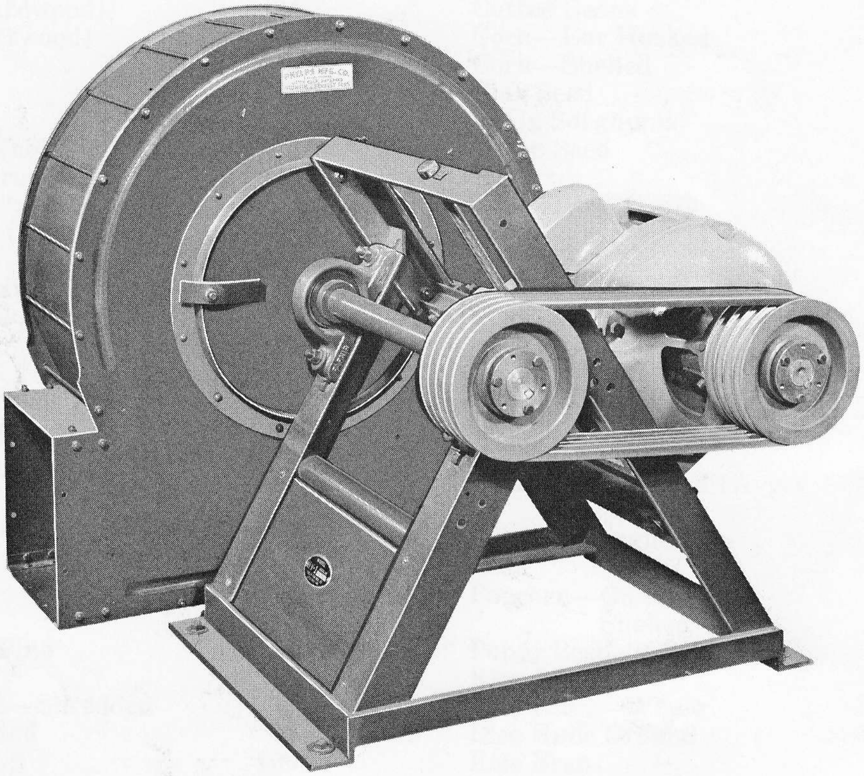
Solid	Lbs. Per Cubic Foot
Asbestos	153
Ashes	43
Calcium Chloride	134
Cellulose	94
Cement	90
Charcoal (Hardwood)	34
Charcoal (Softwood)	23
Cinders	43
Coke (Piled)	28
Cork	15
Corn Cobs (Whole)	12
Corn Cobs (Crushed) 3/8"x3/4"	20
Cotton Loose (Whole)	30
Cotton Seed	26
Cotton Seed Hulls	11
Cotton Seed Meal	37
Flour	47
Flour—Loose	28
Glass—Window	160
Gypsum—Loose	70
Hay—Baled	20
Hay—Loose	6
Ice	59
Leather	56
Mica	183
Paper	58
Pecan Shells	14½
Pulp Chips—Pine	24
Rubber India	58
Rubber—Tire—Shredded	27
Salt, Granulated	48
Sand—Dry	100
Sawdust (Dry)	13
Sawdust—Green (Pine)	26
Shavings, Planer (Dry)	15
Sugar	100
Wood, Pine—Green	60
Wood, Pine—Air Dried	36
Wool, Baled	48
Zonolite	7

TABLE No. 13
Weights of Farm Commodities
Pounds Per Bushel
(One Bushel Equals 1.244 Cubic Feet)

Commodity	Lbs. Per Bushel
Alfalfa Seed	60
Barley	48
Blue Grass Seed	44
Broom Corn Seed	30
Clover Seed	60
Coffee Beans	50
Corn—Ear Husked	70
Corn—Shelled	56
Flax Seed	56
Grain Sorghums	56
Hemp Seed	44
Millet	50
Kafir, Seed	56
Kapok, Seed	40
Lentils, Seed	60
Lespedeza Seed	25
Malt	38
Milo Maize	56
Mustard Seed	60
Nuts—Black Walnut	50
Hickory	50
Oats	32
Peanuts, Unshelled (Avg.)	26
Spanish	30
Virginia	22
Peas	60
Popcorn—On Ear	70
Shelled	56
Poppy Seed	46
Rice—Rough	45
Rice Hulls—Whole	8
Rice Hulls Ground	16
Rice Bran	20
Rye Seed	56
Sesame Seed	46
Sorghum Seed	50
Soybeans	60
Soybean Hulls Ground	27
Soybean Hulls Unground	19
Sudan Grass Seed	40
Sun Flower Seed	32
Timothy Seed	45
Wheat	60

PHELPS—

Model "HV-I" Fan



PHELPS FAN MANUFACTURING COMPANY

LITTLE ROCK, ARKANSAS